POWER PLANT ENGINEERING

Established Over 33 Years

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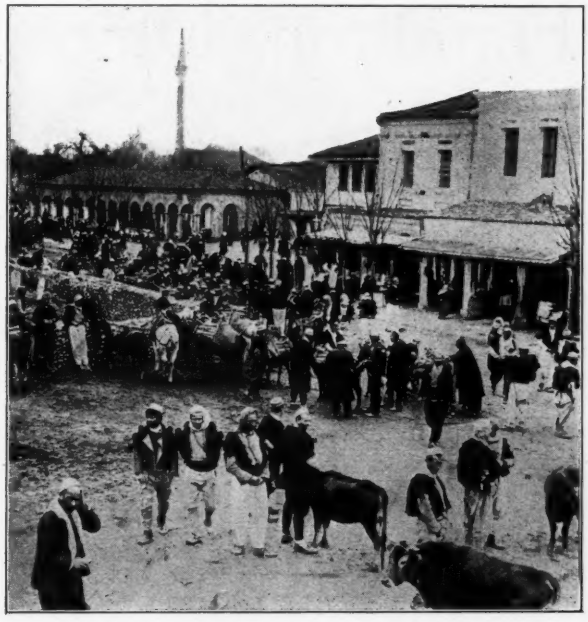


Photo from Ewing Galloway, N. Y.

Modernizing King Zog's Home Town

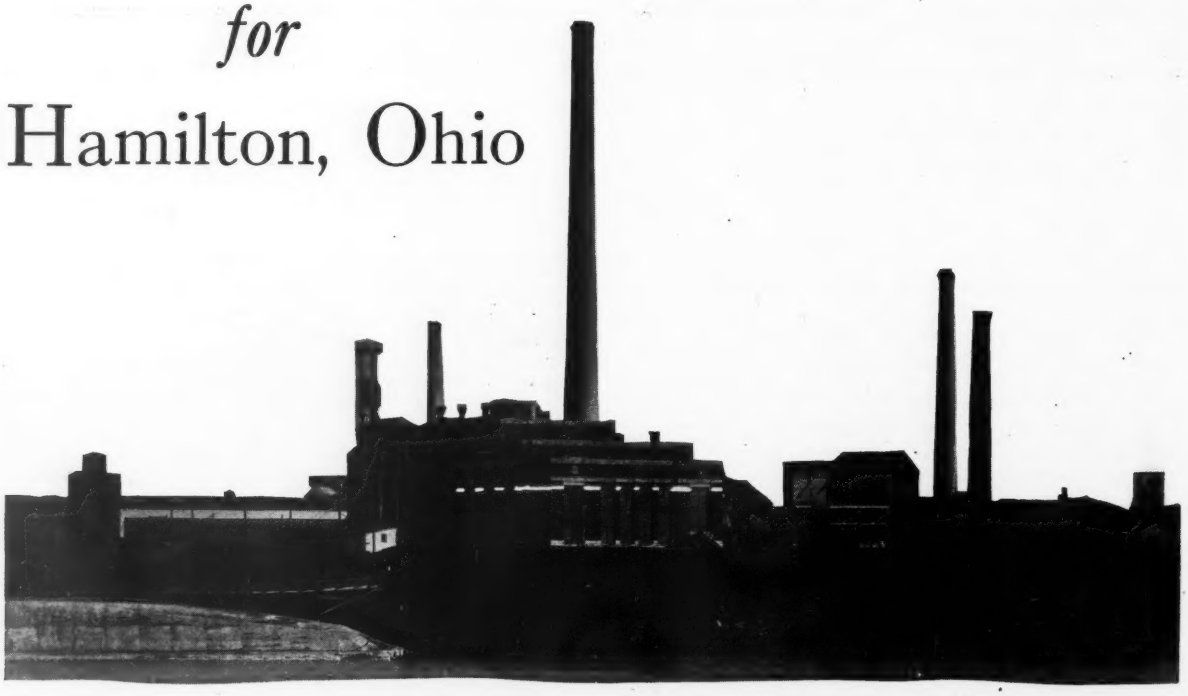
AT LEAST we assume that King Zog is still king of Albania, although, for all we know, another revolution may have occurred since the above picture was taken on the main street of Tirana, his capital. Of course you know all about King Zog; the newspapers were full of him a short time ago, so we won't have to go any further into his story.

His capital is truly a medieval city, with its minarets, quaint buildings and bazaars and the teeming life of the streets, which are crowded with laden donkeys, women carrying water jars on their heads, miscellaneous cattle and the fierce and virile males of the city. (One of our editors says there is a railroad station over in Michigan that looks just like the building with the arches, but he's a low-brow and doesn't appreciate the picturesque.)

Well, only a few weeks ago Tirana was supplied with electric power for the first time. Immediately the American Legation took advantage of the situation to install modern plumbing equipment, consisting of two of the latest type of Flush-Kleen sewage ejectors, supplied by the Chicago Pump Co.

Thus we have an interesting contrast between the two characteristic products of American civilization—electric power and sanitary equipment—and the medieval atmosphere of this interesting old city of Tirana.

New Municipal Power Plant *for* Hamilton, Ohio



MODERN POWER PLANT WITH A CAPACITY OF TWO 3000-KW. UNITS NOW SERVES MUNICIPAL SYSTEM ESTABLISHED IN 1895

ONE OF THE NOTEWORTHY undertakings in municipal ownership is that of the electric plant at Hamilton, Ohio. Since 1895, this city has owned and successfully operated an electric plant but the need for additional capacity grew urgent and as far back as 1920 bonds were voted for a new plant. Litigation, however, delayed construction work on the project until November, 1927, since which time work has been pushed to the completion of the initial installation which was started in operation last January.

In this new plant, which was designed and the construction supervised by The Froehlich & Emery Engineering Co. of Toledo, Ohio, are two 3000-kw. turbine generators, steam for which is supplied by three boilers rated at 500 hp. Another turbine generator of 7500-kw. capacity and an additional 500-hp. boiler have been arranged for in the present building space. The plant can, however, be extended to the north when further capacity is required.

The location of the new plant is just north of the plant which has served the city for some thirty years and is the site of an abandoned gas plant on North Third Street, conveniently located near the tailrace of the Ford water power plant which takes water from the Great Miami River. When the water from the tailrace proves insufficient for the growing demands from the steam plant, a canal can be dug from the main channel of the river so that the supply of condensing water for the new plant will be sufficient to care for all the needs of the city. The condensing water is brought to the plant through two Chain Belt traveling screens. Railway facilities are provided for by a siding from the Baltimore & Ohio Railroad, on which all freight will be handled to and from the plant.

This location is also advantageous in that connection is conveniently made to the old plant and there has been no interruption of service during the construction of the new plant. A substation is located across the street from the plant with a double feeder connection. To the east of the power plant is space for the storage of 12,000 t. of coal, a drag scraper being employed for this purpose.

Strictly fireproof construction was used in the building, the frame being of structural steel and the walls of brick. All doors and stairways are of metal and ample natural light is provided by the steel sash windows and the copper and wire glass skylight over the turbine and boiler room. For the roof, reinforced concrete slabs are used with a layer of cork to prevent condensation. The boiler room is located at the east end of the plant, the turbine room in the middle and the electrical department on the west end. The auxiliary equipment is between the boiler and turbine room, conveniently located on several floors where access may be had between the boilers and turbines. In the turbine room is

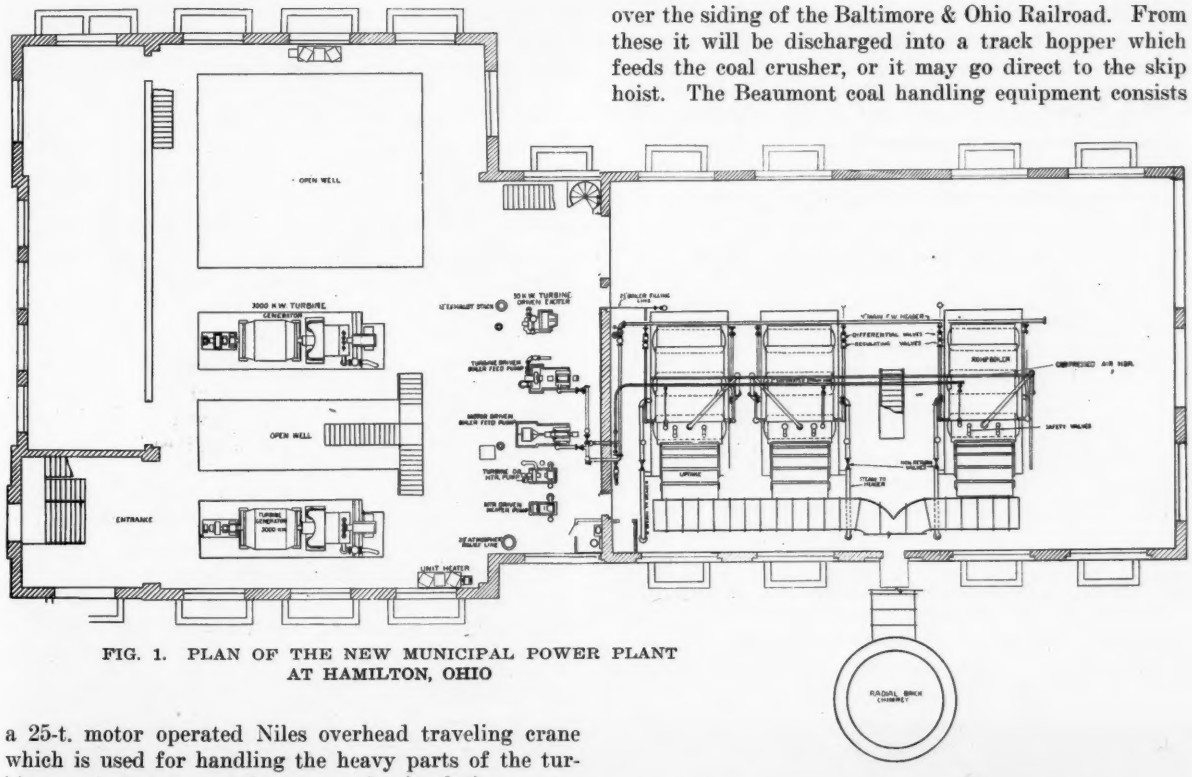


FIG. 1. PLAN OF THE NEW MUNICIPAL POWER PLANT AT HAMILTON, OHIO

a 25-t. motor operated Niles overhead traveling crane which is used for handling the heavy parts of the turbines, generators, condensers and circulating water equipment.

In the electrical section of the building are the main switchboard, remote control switching apparatus, the station transformers and the storage battery equipment. In this section is also located the office of the superintendent where the clerical work of the plant is carried on. A complete system of records is kept, all data being collected and tabulated so that the information on the operation for each day is available to the city manager by noon of the next day. The large part of this information is, of course, collected by the recording instruments.

Coal will come to the plant in hopper bottom cars over the siding of the Baltimore & Ohio Railroad. From these it will be discharged into a track hopper which feeds the coal crusher, or it may go direct to the skip hoist. The Beaumont coal handling equipment consists of a skip hoist which is automatically operated and is used for handling both the coal and ash. The coal delivered to the overhead storage bin of 150 t. capacity is conveyed to the stoker hoppers by means of a weigh larry. The ash discharged from the furnace ash hoppers is conveyed by means of industrial cars to the skip hoist feeding mechanism from which it is elevated to a 50-t. bin, thence chutes discharge the ash to cars or the yard.

When coal is to be stored, it is elevated to a receiving hopper from which it is discharged to the yard for distribution by the yard scraper conveyor which is also used for reclaiming the stored coal. The capacity of

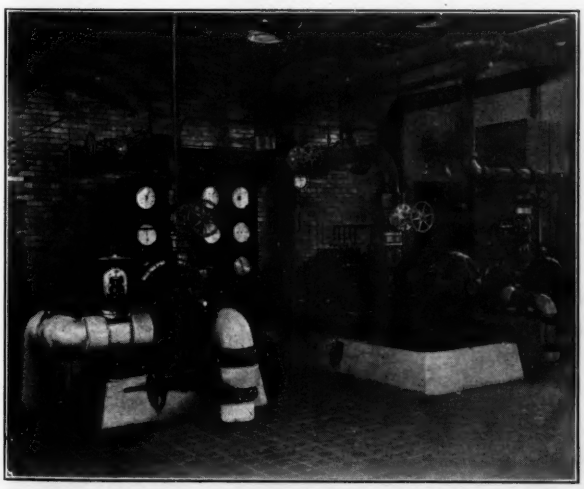


FIG. 2. THESE BOILER FEEDWATER PUMPS ARE LOCATED ON THE OPERATING FLOOR OPPOSITE THE TURBINES

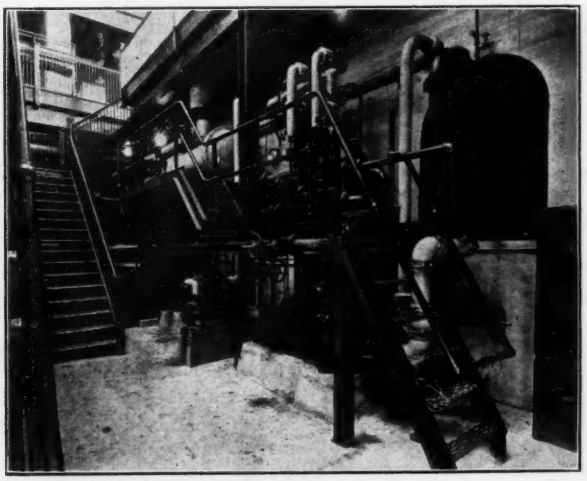


FIG. 3. CONDENSER AUXILIARIES AND ON THE RIGHT THE GENERATOR AIR COOLERS

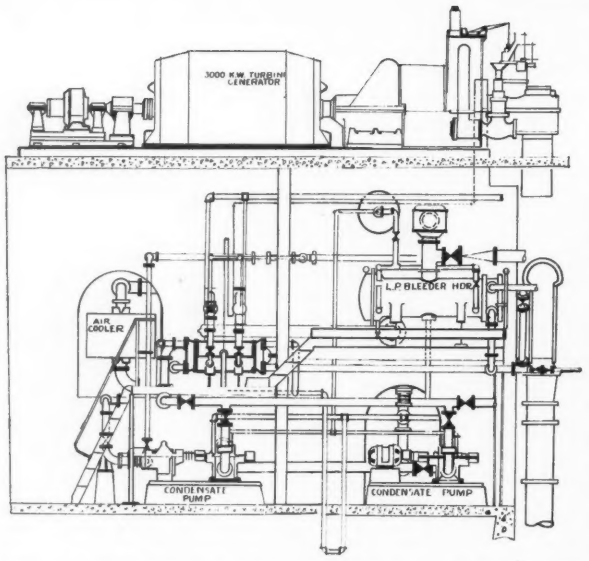


FIG. 4. ELEVATION OF THE TURBINE UNIT SHOWING THE ARRANGEMENT OF CONDENSER AND AUXILIARIES

the skip hoist is 50 t. an hour, the power being furnished by a 15-hp. motor. The entire coal and ash handling equipment is operated by one man and a helper.

Boiler Room Provides for Expansion

At present, three 500-hp. Stirling water-tube boilers constitute the steam generating equipment. Space, however, is available for the installation of one additional unit. These boilers are designed for a steam pressure of 350 lb. and a total temperature of 636 deg. F. (200 deg. of superheat). Serving each of the boilers is a 5-retort Taylor underfeed stoker, driven by a 3-hp. General Electric motor designed for 3-phase, 440-v., 60 cycles and speeds of 1165, 680, 585 and 340 r.p.m. The capacity of this stoker is sufficient to carry the boilers at 250 per cent of rating continuously. In the construction of the furnaces, McLeod & Henry steel mixture refractory blocks are used and the furnaces have liberal combustion space which has been provided to insure low maintenance cost and economical operation.

To supply the forced draft necessary for the operation of the stokers, two American Blower Co. fans are installed in the basement. One of these is driven by a General Electric 60-hp. motor and the other by a Gen-

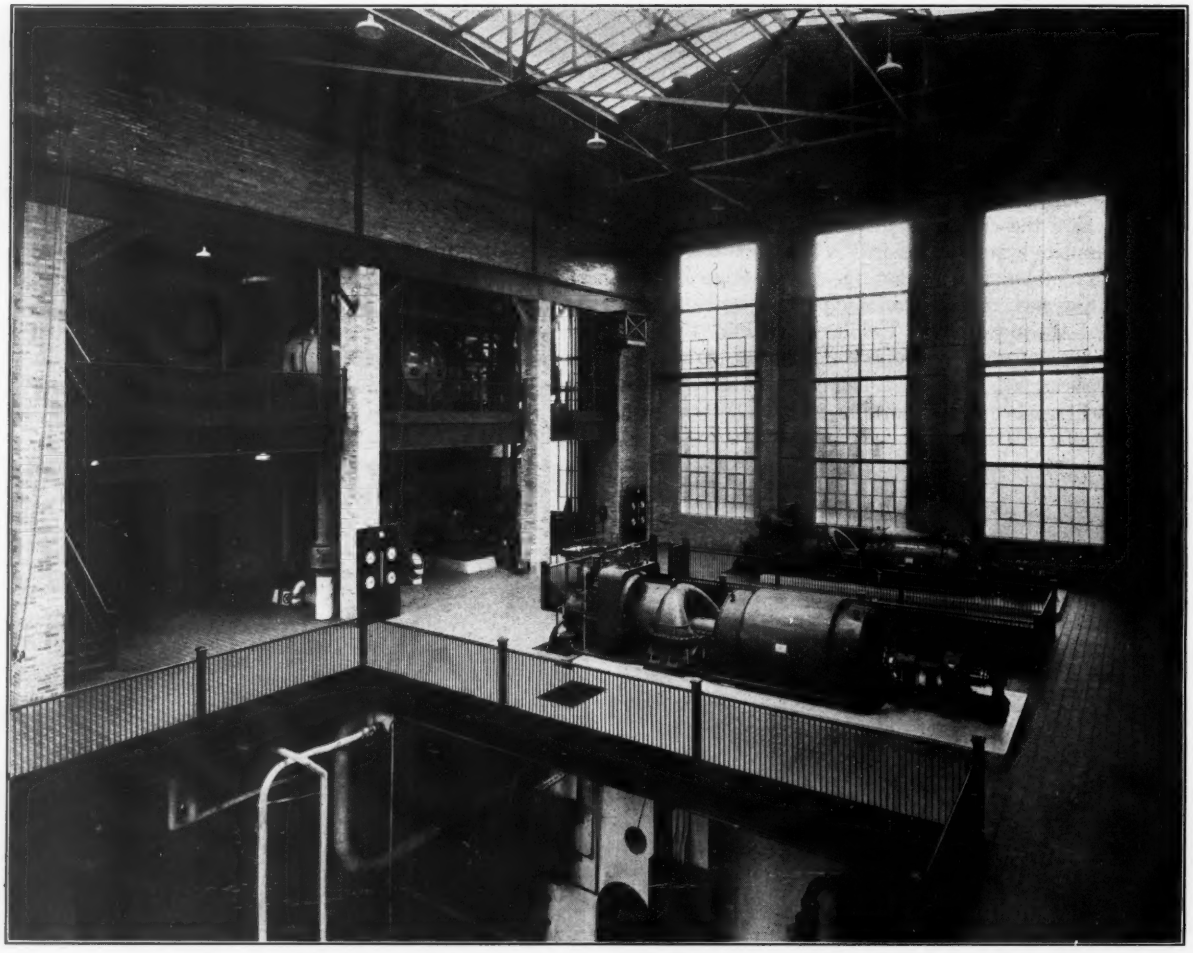


FIG. 5. TWO 3000-KW. TURBO-GENERATOR UNITS ARE INSTALLED WITH SPACE PROVIDED FOR A THIRD UNIT

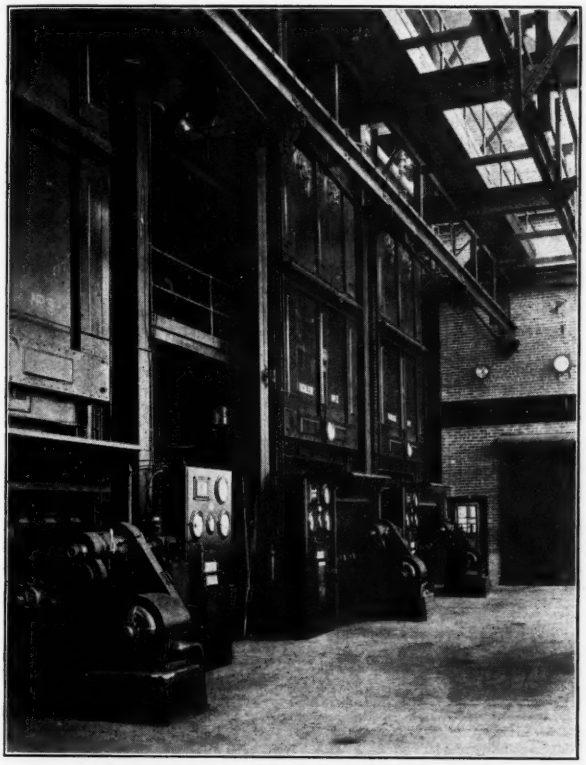


FIG. 6. BOILERS ARE FIRED BY MOTOR-DRIVEN UNDERFEED STOKERS

eral Electric 65-hp. steam turbine. Either of these will furnish sufficient air for two boilers at maximum load. Induced draft necessary for the operation of these boilers under present conditions is furnished by an Alphons Custodis radial brick stack 260 ft. high by 9 ft. 6 in. in diameter at the top connected to the boiler by a Kittoe Boiler & Tank Co. breeching.

As previously stated, additional space is provided for the installation of one more boiler and when conditions justify, induced draft fans and air preheaters will be installed for all four boilers. Building plans will permit the installation of four additional boilers, making eight in all, at a comparatively low cost.

In handling the ash, the stokers discharge into cast-iron ash hoppers where thorough quenching takes place before the ashes are discharged into the industrial cars that take them to the skip hoist. Manually operated roller ash grates are used to control the discharge of the ash from the hoppers to the cars. To prevent the quenching water from flowing into the basement, the gates are designed to collect all water introduced into the hopper and discharge it to the sewer after the fine ash has been separated from the water.

Each of the boilers is provided with a Republic control board, the instruments on each board being a 5-point indicating draft gage, a pressure gage of the indicating type, an indicating steam flow meter, also an integrating steam flow meter, a CO_2 meter of the indicating type, a recording CO_2 meter, a steam flow indicator, a steam temperature indicator, an air preheat temperature indicator and a flue gas thermometer.

For control of the combustion, a Carrick control system has been installed which controls the speed of the stoker, the speed of the forced draft fan and the position of the stack damper, according to the pressure in the boiler. Diamond soot blowers of eight elements each are provided for dusting the tubes and feedwater level is controlled by S-C feedwater regulators.

Makeup feedwater is obtained by distilling raw water from the house service water system. The raw water is fed into an open type Massillon preheater and heated by exhaust steam from the evaporator auxiliaries. From this preheater, the water goes to the high-pressure, double-effect type Griscom-Russell evaporator made by the Griscom-Russell Co. This evaporator, with a high heat level vapor condenser, furnishes distilled water for makeup purposes, the great share of feedwater, of course, coming from the surface condenser.

Turbines Bled at Two Points

In the design of the plant the regenerative cycle is used for heating the boiler feedwater, the main steam turbines being bled at two points. The condensate after leaving the condenser is heated in the inter and after condensers of the air ejectors, in the low-pressure bleeder heaters, which take steam from the low-pressure bleed points of the turbines, and in the Elliott deaerating heater which takes steam from the high-pressure bleed points of the turbines and removes the entrained air which might cause corrosion in the boilers.

Two boiler feed pumps are employed to take the water from the deaerating heaters and pass it to the boilers through the high heat level vapor condenser of the evaporator system. One of these feed pumps is motor driven and the other driven by a turbine. To insure a supply of water to the boilers at all times, a duplicate feedwater piping system has been installed. Also storage has been provided for the hot condensate, cold condensate and raw water.

In the turbine room, the present equipment consists of two 3750-kv-a. Westinghouse turbine generators

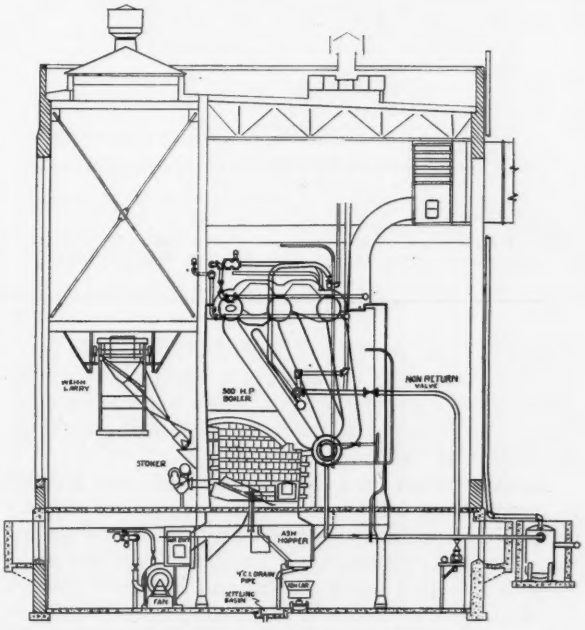


FIG. 7. ELEVATION OF THE BOILER ROOM SHOWING THE BOILER AND STOKER ARRANGEMENT

which are provided with two points of bleeding and each of which has a direct connected exciter. An auxiliary exciter, however, has been provided which consists of a steam turbine-driven, direct-current unit of 50 kw. capacity. The main generators deliver 3-phase, 60-cycle current at 6600-v., rating being given at 80 per cent power factor. There is room in the present building for an additional 7500-kv-a. unit, plans for the installation of which are being made at the present time and when load conditions warrant, an addition of one more bay to the boiler room will permit the installation of the fourth turbine.

Exhaust steam from the turbines discharges directly to Westinghouse 5000-sq. ft. surface condensers directly beneath the turbines. As previously stated, the cooling water for the condensers is obtained from the river through traveling water screens and is forced through the condensers by means of circulating pumps equipped with dual drive, consisting of a motor at one end and a steam turbine at the other. After passing through the condensers, the warm circulating water is returned to the river at a point downstream from the intake.

For each condenser, two condensate pumps are provided. Here again one is motor driven and the other turbine driven. Cooling water is also used in a Griscom-Russell air cooler for the purpose of cooling the ventilating air passing through the generators.

For each turbine, a control board is provided, upon which are mounted a Westinghouse wattmeter, a Tycos mercury column vacuum gage and the following Crosby gages: vacuum, steam pressure, low-pressure bleed and high-pressure bleed.

To aid the operators in handling the feedwater system of the plant, a Republic gage-board has been installed which gives the following indications: Raw water pressure, head in feet; surge tank pressure, head in feet; gland water pressure, head in feet; condenser surge tank, head in feet; two gages giving discharge pressure of the boiler feed pump in pounds per square inch; two gages giving the heater pump discharge pres-

Principal Equipment in Hamilton Municipal Electric Plant

GENERAL

Location of plant.....North Third St., Hamilton, O.
Owner.....City of Hamilton
Capacity, installed.....6000 kw.
Service .....Public Utility
Engineers .....
.....The Froehlich & Emery Engineering Co., Toledo, O.
General building contractor.....Antenen Engineering Co.

STEAM GENERATING EQUIPMENT

3 500-hp. boilers, 350-lb., pressure, 200 deg. superheat, Babcock & Wilcox Co.
3 Stokers, five-retort, underfeed, driven by 3-hp. variable speed, G.E. motor, Taylor—American Engineering Co.
3 Ash hoppers, equipped with hand operated gates and quenchers—Allen-Sherman-Hoff Co.
1 Smokestack, 260 ft. high by 9 ft. 6 in. inside diameter, radial brick type—Alphons Custodis Chimney Co.
1 Forced draft fan, 40,000 c.f.m., motor drive, 60-hp., G.E.—American Blower Co.
1 Forced draft fan, 40,000 c.f.m., 65-hp., G.E. steam turbine drive—American Blower Co.
Furnace refractory—McLeod & Henry Co.
Coal conveying equipment, coal crusher, skip hoist, coal and ash bins, weigh larry, scraper conveyor—R. H. Beaumont Co.
Combustion control systems—Carrick Engineering Co.
High and low water alarms—Reliance Gauge Column Co.
Breechings and air ducts—Kittoe Boiler & Tank Co.
Soot blowers, 8 elements—Diamond Power Specialty Co.
Feedwater regulators, S-C—The Swartwout Co.

TURBINES AND CONDENSERS

2 Steam turbine generators, 3750 kv-a. at 3600 r.p.m., 6600 v., 3-phase, 60-cycle, 80 per cent power factor—Westinghouse Electric & Manufacturing Co.
1 Steam exciter, 50-kw., direct current generator and steam turbine—Westinghouse Electric & Manufacturing Co.
2 Surface condensers, 5000 sq. ft. with air ejectors—Westinghouse Electric & Manufacturing Co.
1 Condensate pump, 1750 r.p.m., 9.5-hp. turbine drive—Westinghouse Electric & Manufacturing Co.
1 Condensate pump, same as above, 10-hp. motor drive—Westinghouse Electric & Manufacturing Co.
2 Traveling water screens—Chain Belt Co.
1 Auxiliary oil pump, steam duplex, 4½ by 3½ by 4 in.—Worthington Pump & Machinery Corp.
Cylinder oil pump—S. F. Bowser & Co.
Air coolers for generators—Griscom-Russell Co.

AUXILIARY EQUIPMENT

1 Deaerating heater—Elliott Co.
2 Bleed heaters—Griscom-Russell Co.
1 High pressure, double effect, evaporator plant—Griscom-Russell Co.
2 Duplex pumps, 4¼ by 3½ by 5 in. for evaporator feed—Worthington Pump & Mach. Corp.
1 Evaporator preheater, Massillon open type—Griscom-Russell Co.
1 Air compressor—Gardner-Denver Co.
1 Boiler feed pump, 250 g.p.m., 2500 r.p.m., 1050 ft. head, Westinghouse turbine drive, 125 hp.—Ingersoll-Rand Co.
1 Boiler feed pump, 250 g.p.m., 1050 ft. head, 1750 r.p.m., 125 hp., Westinghouse motor drive—A. S. Cameron Steam Pump Works.
1 Service water pump, 250 g.p.m., 125 ft. head, 15 hp., G.E. motor drive, 3450 r.p.m.—Moore Steam Turbine Co.
1 Service water pump, 250 g.p.m., 125 ft. head, 12-hp., Moore Steam Turbine drive, 3450 r.p.m.—Moore Steam Turbine Co.
Oil coolers—Andale Co.

PIPING AND VALVES

Piping contractor—American Power Piping Corp.
Steam and water pipe—Crane Co., A. M. Byers Co.
Valves—Lunkenheimer Co.
Pipe fittings—Crane Co., Walworth Co.
Steam pipe covering—The Philip Carey Co.
Steam traps—Strong, Carlisle & Hammond Co.; The C. E. Squires Co.
Atmospheric relief, flow, and back pressure valves—Cochrane Corp.
Blowoff valves—Yarnall-Waring Co.
Safety valves—Consolidated Ashcroft-Hancock Co.

INSTRUMENTS

Draft gages—Republic Flow Meters Co.
Steam flow meters—Republic Flow Meters Co.
Water flow meters—Republic Flow Meters Co.
Pressure gages—Crosby Co.
CO_2 meters—Republic Flow Meters Co.
Recording temperature thermometers—Republic Flow Meters Co.
Recording pressure gages—Bristol Co.
Vibration trachometers on turbines—James G. Biddle
Switchboard instruments—Westinghouse Electric & Manufacturing Co.

ELECTRICAL EQUIPMENT

3 House service power transformers, single-phase, 60-cycle, 150 kv-a., high-tension voltage, 6600, low-tension voltage, 460, 230, 115, type S.K.—Westinghouse Electric & Manufacturing Co.
2 House lighting transformers, single-phase, high-tension voltage, 460 and 230, low-tension voltage 230 and 115, 25-kv-a. type S.—Westinghouse Electric & Manufacturing Co.
Storage battery charging set, motor generator charger, 3-hp., 440-v., 3-phase motor, 1.5-kw., 140-v., d.c. generator, 1750 r.p.m.—Westinghouse Electric & Manufacturing Co.
Storage battery, 60 cell, Exide, type E7—Electric Storage Battery Co.
Switchboard and switch gear—Westinghouse Electric & Manufacturing Co.
Switch cell structures—Deceleco, Inc.
Power circuit wiring—Kelso-Wagner Co.
Lighting circuit wiring—Walker Co.

MISCELLANEOUS

Structural steel—Jones & Lathrop Co.; Carnegie Co.
Subway grating—Irving Iron Works Co.
Cork insulation—Armstrong Cork Co.
1 Traveling crane, 25 t., in turbine room—Niles Crane Co.
2 Unit heaters, one in boiler room and one in switch house basement, Westinghouse fan motor drive—York Heating & Ventilating Corp.

sure in pounds per square inch; a water flow meter reading pounds per hour; an integrating water flow meter; a steam pressure gage, reading pounds per square inch, and a recording instrument giving the water flow, water temperatures before and after deaerating heater, and water temperature after vapor condenser.

Switches Are Housed in Cell Structure

Leads from the generators to the switch gear buses consist of copper bars mounted in compartments. The main switch gear, manufactured by the Westinghouse Electric & Mfg. Co., consists of oil circuit breakers, which with their disconnecting switches, buses and connections, are mounted in a Zellite cell structure. The oil circuit breakers are mounted in the cell room under

FIG. 8. MAIN SWITCHBOARD WITH SUPERINTENDENT'S OFFICE IN THE BACKGROUND

the switchboard, at the turbine floor level, and are controlled from a straight, vertical type switchboard on a gallery in the switchboard bay above the cell room overlooking the turbine room, a storage battery being installed for the operation of the circuit breakers and for furnishing emergency lighting.

Space has been provided in the cell structure for two future generators and three future feeders. This entire layout has been so constructed and installed as to permit its expansion to a full double-bus double-breaker installation in the future.

To supply the house service, the switch gear consists of Westinghouse, electrically-operated, frame-mounted oil circuit breakers erected in the basement of the switchboard bay. On each of the seven panels of this board are mounted one ammeter and two overload relays and a remote controlled switch. Three single-phase transformers are installed to supply the power circuit, each having a capacity of 150 kv-a. and giving a voltage ratio of 6600 to 440 v. For the lighting circuit, two single-phase transformers are employed, each being rated at 25 kv-a. with primary voltage of 460 and secondary voltage of 115 and 230 v.

In the storage battery equipment, 60 Exide cells are employed, the charging being accomplished by a motor-generator set manufactured by Westinghouse. This consists of a 3-hp., 440-v., 3-phase motor, driving a 1.5-kw., 140-v., d.c. generator at 1750 r.p.m., the control board having mounted upon it one voltmeter, one ammeter and the necessary switches.

All outgoing circuits leave the plant underground from a cable room located below the cell structure housing the main switch gear and feed a galvanized steel outdoor transforming substation that has been installed adjacent to the plant and at present is used to step the voltage from 6600 down to 4000, at which the current is delivered underground to the old distributing board in the old generating station. Future plans, however, call for the expansion of this substation, at which time it will also be used as a step-up station, transforming from generator voltage to a higher voltage for transmission to outlying substations. When this takes place, one unit of this substation will be used to step-down the voltage to 4000 v., delivering power to a distributing board to be installed in the new plant for serving the territory adjacent to the new plant. With the installation of the outlying substations and a distributing board in the new plant, the old generating station will be used only for water works purposes and for the storage of supplies for the city's gas, water and electric properties.

As the plant now stands, exclusive of real estate and interest during construction, the cost is approximately $900,000. This is equivalent to a unit cost of

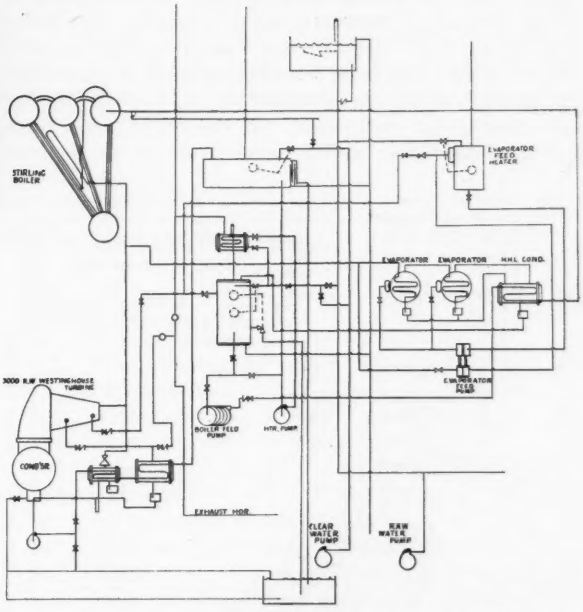


FIG. 9. STEAM FLOW DIAGRAM OF STATION

$150 per kw. capacity, or $120 per kv-a. As the plant, however, was designed for considerable expansion, when the third unit of 7500 kw. capacity is installed, the cost per kilowatt of the entire plant will be reduced to $92.60.

Much of the success that the city of Hamilton has had with its municipal undertakings is credited by its citizens to the managerial form of government under which it operates and to the efforts of its city manager, R. P. Price, to run the municipal plant on an economical basis.

With a simple D valve, it is impractical to have cutoff occur too early in the stroke, because, in order to obtain a satisfactory width of opening in such cases it is necessary to have the valve and lap excessively large or to have release and compression occur too early in the stroke.

Study *your boiler losses* For Better Efficiency

by Jay G. Huntoon

Plant Engineer, Riverside Station, United Light & Power Co., Davenport, Iowa

[*Frequent calculation of Losses and the laying out of a maximum value of each controllable loss will tend to bring boiler room operation on a more consistent basis*]

THERE CAN BE no question that the boiler room is the keynote of successful plant operation. The boiler room force deals with the raw materials, that is, coal, air and water, and from these materials, it is their duty to produce steam, as economically and efficiently, as operating conditions permit. If the boiler room force functions efficiently, and delivers steam on an economical basis to the prime mover, at the conditions that prime mover demands, then the largest and hardest part of the operating cycle is completed.

To maintain the boiler room on such a basis, it is necessary to know where the heat goes and why it goes there. The heat balance is the solution and through it, we may segregate the different losses, and through this

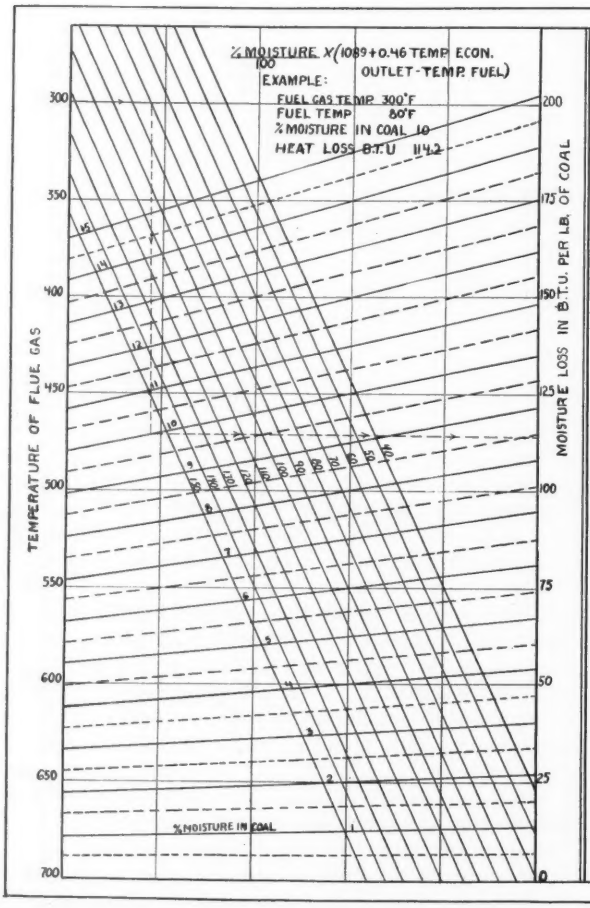

% MOISTURE X (1089+0.46 TEMP. ECON. OUTLET-TEMP. FUEL)
100
EXAMPLE:
FUEL GAS TEMP. 300°F
FUEL TEMP. 80°F
% MOISTURE IN COAL 10
HEAT LOSS B.T.U. 1142
TEMPERATURE OF FLUE GAS
MOISTURE LOSS IN B.T.U. PER LB. OF COAL
% MOISTURE IN COAL

FIG. 1. HEAT LOSS DUE TO THE MOISTURE IN THE COAL DEPENDS UPON THE EXIT GAS TEMPERATURE

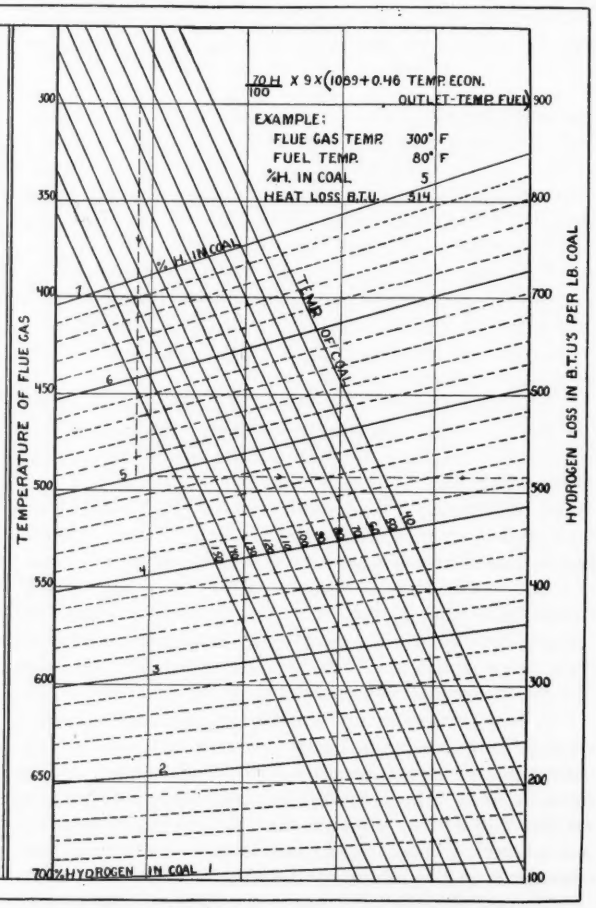

% H. X 9 X (1089+0.46 TEMP. ECON. OUTLET-TEMP. FUEL)
100
EXAMPLE:
FLUE GAS TEMP. 300° F
FUEL TEMP. 80° F
%H. IN COAL 5
HEAT LOSS B.T.U. 514
% H. IN COAL
TEMP. OF COAL
TEMPERATURE OF FLUE GAS
HYDROGEN LOSS IN B.T.U'S PER LB. COAL
% HYDROGEN IN COAL

FIG. 2. HEAT LOSS DUE TO WATER VAPOR FORMED BY THE COMBUSTION OF HYDROGEN IN THE COAL

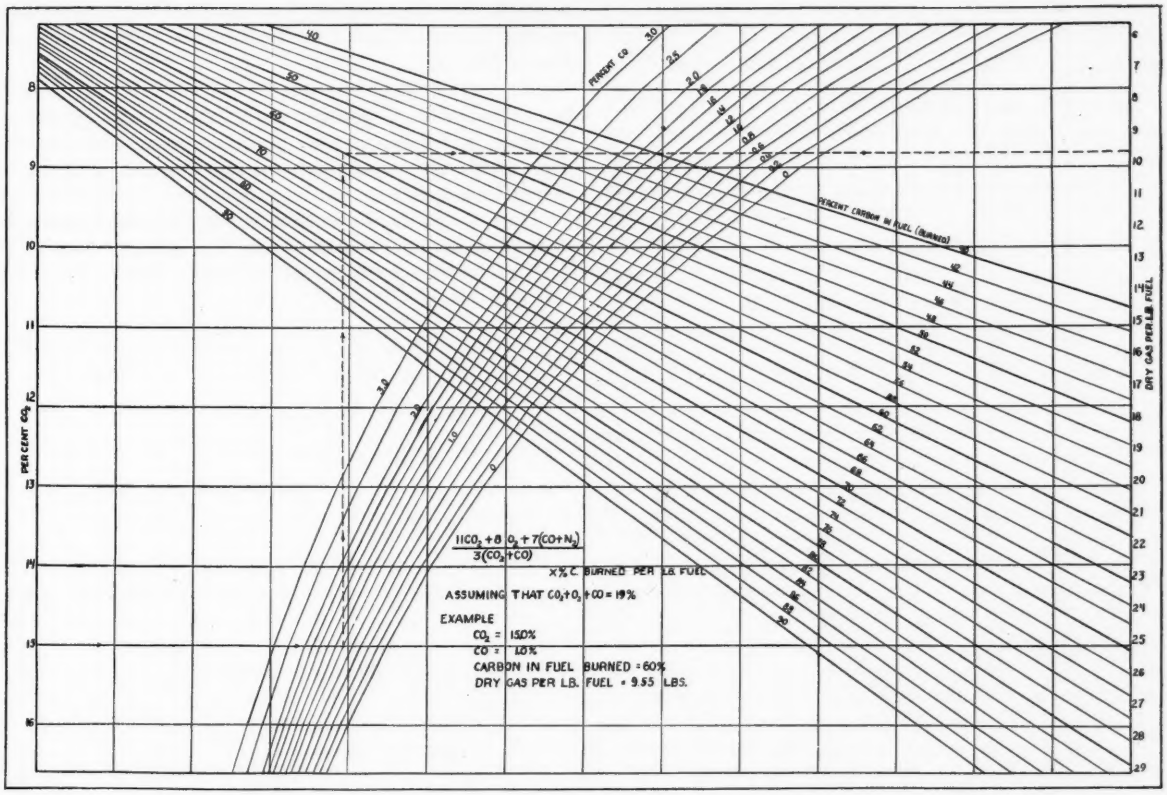


FIG. 3. CHART FOR CALCULATING THE WEIGHT OF DRY FLUE GAS FORMED PER POUND OF FUEL BURNED

information cut down each of these losses to a minimum. This cutting down of losses is a first requisite to good operation. This article does not attempt to point out the different ways of cutting down these losses, but simply to point out an easy way of determining what these losses are.

Curves and charts used were made to check these losses at the Riverside Station of the United Light & Power Co. These plates were not made for the solution of tests but were made with the idea of checking actual operation results. They are based on the A. S. M. E. boiler test code heat balance, and can be used for test work. The greatest use for them at the Riverside Station, however, is in checking erratic firing conditions, and in this use, they have proven most valuable.

It must be remembered that boiler room calculations and analysis are far from an exact science, and any calculations made are bound to be in error to some extent. It is practically impossible to get absolutely true readings. Water and coal may be weighed, and these readings accepted as true, but flue gas readings are very likely to be in error, as a traverse across the pass will show considerable variation.

These flue gas readings and coal and ash analysis must be taken as a basis for your calculations, and the possibility of error in initial figures is too great to make the final solution absolutely accurate. The figures will be plenty accurate enough to show the trend, however, and a careful manipulation of the orsat, with careful sampling of the coal and ash, will do much toward lessening the error.

The A. S. M. E. Test Code for Sationary Steam Boilers in Table S 1 B, gives the following short form of heat balances:

1. Heat absorbed by water and steam in boiler and superheaters
2. Heat absorbed by water in economizers
3. Heat loss due to moisture in coal
4. Heat loss due to water from combustion of hydrogen
5. Heat loss due to moisture in air
6. Heat loss due to dry chimney gases
7. Heat loss due to incomplete combustion of carbon
8. Heat loss due to unconsumed combustible in refuse.
9. Unaccounted for losses.

Items 1 and 2 are not losses and will be passed over briefly. They can be grouped together under the heading of useful work figuring the boiler and economizer as an integral unit, this heat absorption can be readily calculated from the water evaporated per pound fuel and the heat in the steam minus heat in the water delivered to the economizer.

For calculating the various losses, Items 3 to 7, charts have been made. The use of these charts is best illustrated by an actual example and for this purpose the following figures will be used:

Gas, temperature economizer outlet	300 deg. F.
Room, temperature of	80 deg. F.
Temperature of fuel	80 deg. F.
Carbon burned per lb. coal	60 per cent
Moisture in coal	10 per cent
Hydrogen in coal	5 per cent
Ash	11 per cent
Refuse	16 per cent

CO_2	15 per cent
O_2	3 per cent
CO	1 per cent
N_2	81 per cent

Item 3, the loss due to moisture in the coal, is easily calculated, being the heat absorbed by the moisture through the range from the firing temperature of the fuel to the gas temperature at the economizer discharge.

The A. S. M. E. Code gives the following formula for calculating this loss:

(% moisture in coal ÷ 100) × (1089 + 0.46 × Temp. Econ. Out. — Temp. Fuel)

which becomes, after substituting the proper values:

$(10 \div 100) \times (1089 + 0.46 \times 300 - 80) = 114.7$ B.t.u.

perature, 80, then vertically to the percentage of hydrogen in the coal, 5, and then horizontally to the hydrogen loss of 514 B.t.u.

Item 5, the heat loss due to the moisture in the air, is, in the writer's opinion, negligible and can be safely grouped under the unaccounted for losses. It is a loss over which there is no control and because it is small, is best left alone.

Item 6, the heat loss due to dry chimney gases, is dependent on the weight of dry flue gas per pound of fuel, and this should be solved first. The formula for this solution is:

$$\frac{11\,CO_2 + 8\,O_2 + 7\,(CO + N_2)}{3\,(CO_2 + CO)} \times \frac{\text{Per cent carbon burned}}{160}$$

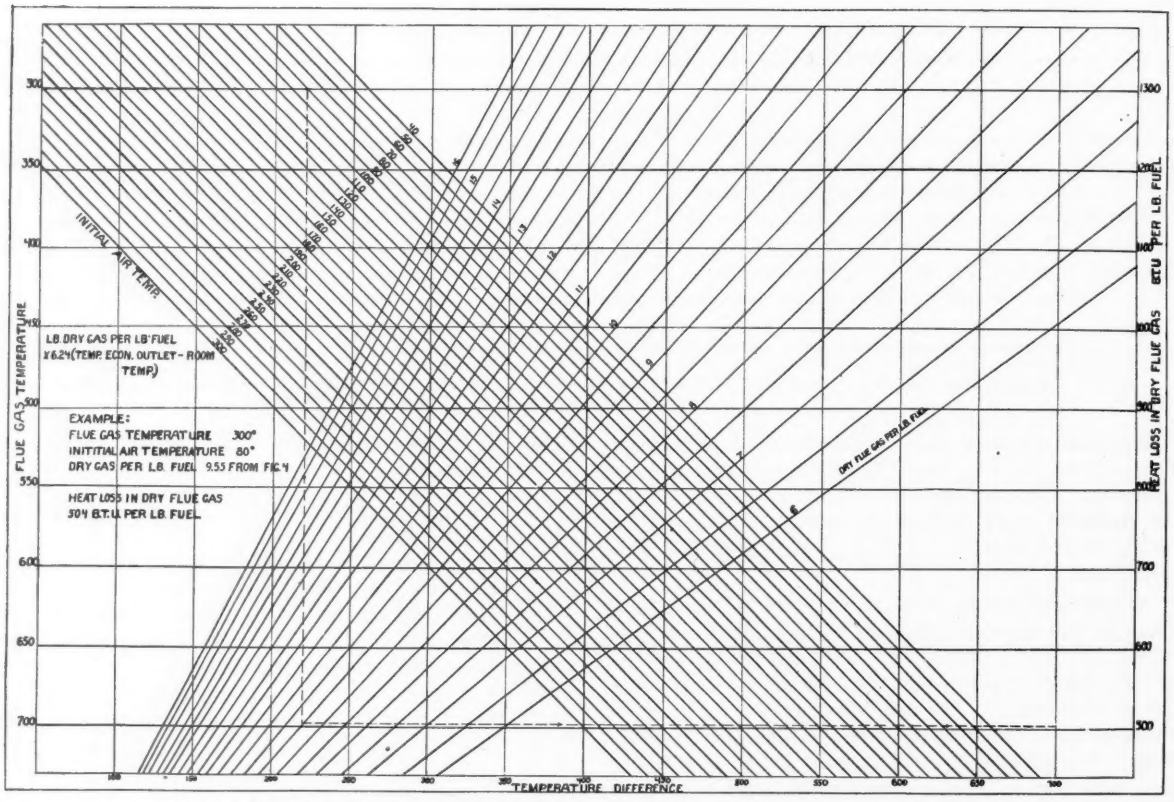

FLUE GAS TEMPERATURE
INITIAL AIR TEMP.
LB. DRY GAS PER LB. FUEL
X 6.24 (TEMP. ECON. OUTLET - ROOM TEMP.)
EXAMPLE:
FLUE GAS TEMPERATURE 300°
INITITIAL AIR TEMPERATURE 80°
DRY GAS PER LB. FUEL 9.55 FROM FIG. 4
HEAT LOSS IN DRY FLUE GAS
304 B.T.U. PER LB. FUEL
DRY FLUE GAS PER LB. FUEL
TEMPERATURE DIFFERENCE
HEAT LOSS IN DRY FLUE GAS B.T.U. PER LB. FUEL

FIG. 4. HEAT LOSSES DUE TO DRY CHIMNEY GASES (ASSUMING THAT $CO_2 + CO + O_2$ IS EQUAL TO 19)

This loss can also be found from Fig. 1 by entering at the flue gas temperature, 300, reading horizontally to the fuel temperature, 80, then vertically to per cent moisture in the coal, 10, and finally horizontally to the moisture loss in the coal which is found to be 114.2 B.t.u.

Heat loss due to the combustion of hydrogen is a similar formula, the parenthetical parts being identical with the previous. This formula is given as:

% hydrogen ÷ 100 × 9 × (1089 + 0.46 × Temp. Econ. Out. — Temp. Fuel)

which becomes:

$5 \div 100 \times 9 \times (1089 + 0.46 \times 300 - 80) = 516$ B.t.u.

In finding this from Fig. 2, enter at the temperature of the flue gas, 300, read horizontally to the fuel temperature, 80, then vertically to the percentage of hydrogen in the coal, 5, and then horizontally to the hydrogen loss of 514 B.t.u.

Item 5, the heat loss due to the moisture in the air, is, in the writer's opinion, negligible and can be safely grouped under the unaccounted for losses. It is a loss over which there is no control and because it is small, is best left alone.

Item 6, the heat loss due to dry chimney gases, is dependent on the weight of dry flue gas per pound of fuel, and this should be solved first. The formula for this solution is:

$$\frac{11\,CO_2 + 8\,O_2 + 7\,(CO + N_2)}{3\,(CO_2 + CO)} \times \frac{\text{Per cent carbon burned}}{160}$$

Upon substantiating the figures, this becomes:

$$\frac{11 \times 15 + 8 \times 3 + 7\,(1 + 81)}{3\,(15 + 1)} \times \frac{60}{100} = 9.53 \text{ lb.}$$

In the curves, Fig. 3, entering at a CO_2 reading, 15, horizontally to the CO reading, 1.0, vertically to the carbon burned per pound of fuel, 60, and then horizontally to the dry gas per pound of fuel, the amount is found to be 9.55 lb. per lb. of fuel.

This set of curves is plotted on the assumption that $CO_2 + CO + O_2$ equals 19, but the error for other reasonable flue gas readings will be small.

Having calculated the dry gas per pound of fuel, the heat loss can be calculated from the following formula:

Dry gas per lb. fuel × 0.24 (Gas temp. econ. outlet — Room temp.) which becomes:

$$9.53 \times 0.24\ (300 - 80) = 503.2 \text{ B.t.u.}$$

Entering the chart, Fig. 4, at a flue gas temperature of 300, reading horizontally to the initial air temperature of 80, vertically to the dry gas per pound of fuel, 9.55 and then horizontally to the heat loss in the dry flue gas which is found to be 504 B.t.u.

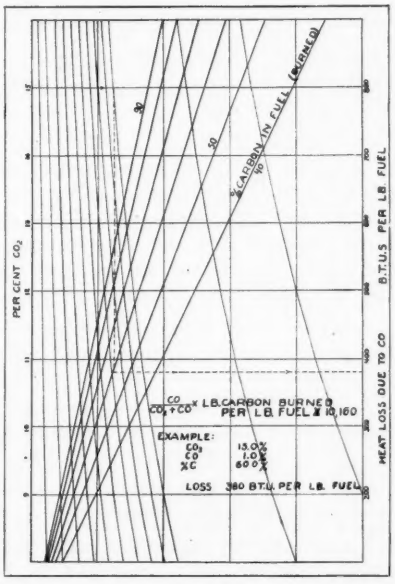

PER CENT CO2
B.T.U.S PER LB. FUEL
HEAT LOSS DUE TO CO
% CARBON IN FUEL (BURNED)
CO / CO2+CO × LB. CARBON BURNED PER LB. FUEL × 10,160
EXAMPLE:
CO2 15.0%
CO 1.0%
%C 60.0%
LOSS 380 B.T.U. PER LB. FUEL

FIG. 5. LOSSES DUE TO INCOMPLETE COMBUSTION OF CARBON FORMED IN THE FLUE GASES

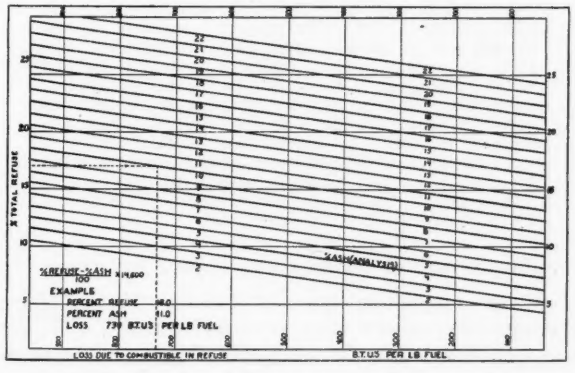

% TOTAL REFUSE
% REFUSE - % ASH / 100 × 14,600
EXAMPLE
PERCENT REFUSE 16.0
PERCENT ASH 11.0
LOSS 730 B.T.U.S PER LB FUEL
% ASH (ANALYSIS)
LOSS DUE TO COMBUSTIBLE IN REFUSE
B.T.U.S PER LB FUEL

FIG. 6. IN MANY CASES, LOSSES DUE TO UNBURNED CARBON IN THE REFUSE ARE A CONSIDERABLE ITEM

The heat loss due to incomplete combustion of carbon, Item 7, is figured from the formula:

$$\frac{CO}{CO_2 + CO} \times \text{carbon burned per pound of fuel} \times 10{,}160,$$

with the proper values this becomes:

$$\frac{1}{15 + 1} \times \frac{60}{100} \times 10{,}160 = 381 \text{ B.t.u.}$$

From the curves, Fig. 5, entering at a CO_2 reading of 15, read horizontally to CO reading of 1.0, vertically to carbon burned per pound of fuel, 60, and then horizontally to the heat loss due to CO or 380 B.t.u.

Heat loss due to unburned combustible in the refuse, Item 8, is figured from the formula:

$$\frac{\text{Per cent refuse} - \text{per cent ash}}{100} \times 14{,}600, \text{ which becomes on substituting proper figures:}$$

$$\frac{16 - 11}{100} \times 14{,}600 \text{ or } 730 \text{ B.t.u.}$$

Using the curves, Fig. 6, entering at the top with a per cent of total refuse, 16, read down to the per cent ash of 11, and then horizontally to the loss due to unburned combustible of 732 B.t.u.

Comparing results of calculations by the formulas and the curves gives the following results:

	Formula	Curves	Diff.
3. Loss due to moisture in coal	115	114	+1
4. Loss due to hydrogen in coal	516	514	+2
5. Loss due to moisture in air	—	—	—
6. Loss due to dry flue gas	503	504	—1
7. Loss due to incomplete combustion	381	380	—1
8. Loss due to unburned combustible	730	732	+2
		Total Difference	3

Unaccounted for losses are naturally the difference between the heating value of the coal and the heat accounted for both in losses and absorption.

It is not the intent of this article to explain what to do after calculating the losses. Each engineer has his own problems that can best be solved by applying the charts to his own particular problems after a thorough study. But the frequent calculation of these losses and the laying out of a maximum value for each controllable loss, will tend to bring boiler room operation on a more consistent basis. With the use of the curves, these calculations may be made within the space of fifteen minutes. The saving of time in calculation and the ease of checking boiler results have proven their value at this station.

ORDER FOR FOUR large hydraulic turbines and generators has just been placed, for shipment to the Soviet Union by the Amtorg Trading Corp., with the Newport News Shipbuilding and Dry Dock Co. and the International General Electric Co., according to an announcement made recently by Saul G. Bron, Chairman of the Amtorg. "The order involves an outlay of about $2,500,000," said Mr. Bron, "and we are pleased to state that credit terms up to five years were granted, the payments to be made along the lines laid down in our recent agreement with the International General Electric Co. Offers were received from a number of countries but American equipment won out in this international competition, being considered the most suitable for the purpose. The equipment, consisting of four hydraulic turbines, of 80,000-hp. capacity each, direct connected to four vertical generators of 77,500-kv-a. capacity each, and all necessary accessories, will be used in the Dnieper hydroelectric plant now being constructed near Dniepropetrovsk in the Ukrainian Soviet Republic and will be the first of 10 similar units to be installed in this plant, which will be the largest electric station in Europe."

Boiler Feedwater Should Be Free from Oxygen

OXYGEN DETERMINATIONS SHOULD BE MADE AT THE FIRST INDICATION OF CORROSION. THE WINKLER IODIMETRIC METHOD GIVEN IN DETAIL BELOW WAS TAKEN FROM THE CHEMISTS SUBCOMMITTEE REPORT OF THE PRIME MOVERS COMMITTEE OF THE N.E.L.A.

PRESENCE OF DISSOLVED OXYGEN in water used for boiler feed is objectionable, since it increases the corrosive properties of the water. It is essential in steam station operation that the dissolved oxygen content of the feedwater be kept as low as possible. In order to control the dissolved oxygen, tests should be made at frequent intervals.

Application of the Winkler method, described in detail below, is intended for use on all boiler feedwater supplies except raw water. If organic matter, nitrates or iron salts are present in appreciable amounts the Rideal-Stewart method should be applied. After further investigation, it may be possible to indicate the permissible amounts of organic matter, nitrites or iron salts under which the method outlined may be employed.

TABLE I. REACTIONS IN THE WINKLER TEST FOR DISSOLVED OXYGEN

(1)	$MnCl_2$ Manganous Chloride	+ 2 KOH Potassium Hydroxide	=	$Mn(OH)_2$ Manganous Hydroxide	+ 2 KCl Potassium Chloride		
(2)	2 $Mn(OH)_2$ Manganous Hydroxide	+ O_2 Oxygen	=	2 H_2MnO_3 Manganous Acid			
(3)	2 KCl Potassium Chloride	+ H_2SO_4 Sulfuric Acid	=	K_2SO_4 Potassium Sulfate	+ 2 HCl Hydrochloric Acid		
(4)	$Mn(OH)_2$ Manganous Hydroxide	+ H_2SO_4 Sulfuric Acid	=	$MnSO_4$ Manganous Sulfate	+ 2 H_2O Water		
(5)	H_2MnO_3 Manganous Acid	+ 4 HCl Hydrochloric Acid	=	$MnCl_2$ Manganous Chloride	+ 3 H_2O Water	+ Cl_2 Chlorine	
(6)	2 KI Potassium Iodide	+ Cl_2 Chlorine	=	2 KCl Potassium Chloride	+ I_2 Iodine		
(7)	2 $Na_2S_2O_3$ Sodium Thiosulfate	+ I_2 Iodine	=	$Na_2S_4O_6$ Sodium Tetrathionate	+ 2 NaI Sodium Iodide		

The Winkler Iodimetric method depends upon the liberation in the solution of an amount of iodine exactly proportional to the amount of oxygen dissolved. Chemically, it amounts to the oxidation of the manganous chloride solution to manganic acid by the oxygen present, and a subsequent reduction of iodide by the manganic acid. The starch indicator indicates the presence of iodine, and the standardized solution of sodium thiosulphate has a definite iodine absorbing value. The calculations by the formula are in terms of oxygen, but the intermediate steps are computed in terms of iodine. The reactions involved are given in the table.

TABLE II. LIST OF APPARATUS USED FOR MAKING THE DETERMINATIONS

1. Copper cooling coil.
2. Rubber tubing, heavy wall, ¼ in. bore, ⅛ in. wall.
3. Flint glass bottles, narrow mouth with mushroom glass stopper ground to a point. Capacity, 8 oz. for collecting samples.
4. Flint glass bottles, narrow mouth for rubber stoppers. Capacity, 8 oz. for reagents. (The number of sample bottles required is optional, depending on the number of sampling points in the station.)
5. One bottle dropping TK type, flat glass stopper, 125 ml. capacity, for starch solution.
6. One glass cylinder, heavy base and lip for pouring, capacity 250 ml., subdivisions 2 ml.
7. One casserole, porcelain, glazed both sides, flat bottom, pour out, and porcelain handle, capacity 375 ml., size No. 4.
8. One burette with straight glass stop-cock, capacity 10 ml., subdivision 0.05 ml.
9. One apparatus support, rectangular base 4 by 6 in., length of rod 18 in.
10. One Universal burette clamp, rubber covered jaws.
11. Four pipettes, transfer type, bulb in center, graduated to deliver 2 ml. fitted with 2 in. of pure gum rubber tubing.

For making this determination, suitable apparatus as indicated in Table II is advisable. Five reagents are used and directions for their preparation are given below. When facilities for the preparation of these reagents are not available they can be purchased from any reliable chemical supply house. These reagents are:

1. Manganous chloride. Dissolve 425.5 grams of crystalline manganous chloride C.P. ($4H_2O$) in 1000 c.c. of distilled water.
2. Alkaline potassium iodide. Dissolve 700 grams of potassium hydroxide (c.p.) and 150 grams of potassium iodide (c.p.) separately in distilled water and dilute the mixture to 1000 c.c.
3. Sulphuric acid. Equal volumes of c.p. concentrated acid (sp.gr. 1.84) and distilled water.
4. Starch solution. Dissolve 5 grams of Litner's soluble starch in 50 c.c. of distilled water to make a thin paste, and then pour into 200 c.c. of boiling distilled water and continue boiling for four or five minutes. When cold, add a few drops of chloroform and keep this solution in a dark glass stoppered bottle. Starch solution does not keep well and should be made up fresh every week.
5. Sodium thiosulfate. 0.025 N solution. Dissolve 6.205 grams of chemically pure recrystallized sodium thiosulphate in distilled water and dilute the solution to 1000 c.c. with freshly boiled and cooled-distilled water. Each c.c. is equivalent to 0.2 mg. of oxygen, or to 0.1395 c.c. of oxygen at 0 deg. cent. and 760 mm. pressure. Inasmuch as this solution is not permanent, it should be standardized weekly against a 0.025 N solution of potassium dischromate or 0.025 N solution of potassium permanganate. If special investigations are being made, the thiosulfate should be calibrated daily.

COLLECTION OF SAMPLE AND ADDING REAGENTS

Water supplies in excess of 125 deg. F. and above atmospheric pressure shall be cooled through a copper coil condenser, throttled at the discharge end to room temperature. Sufficient construction details for making a suitable cooling coil are shown in Fig. 1.

A narrow-necked glass stoppered bottle of 250 to 300 c.c. capacity, as shown in Fig. 2, is satisfactory for taking a sample. To the end of the sample connection attach, by means of heavy-walled rubber hose, a glass tube, which will permit filling the bottle by displacement of the air and water by overflowing. The minimum rate of filling should be 250 c.c. per 30 sec. and the sample bottle should be permitted to overflow not less than 5 minutes. This procedure insures the complete removal of air in the bottle and subsequent solution in the water of such air.

Make certain that the sample line from the source of sampling to the bottle has been freed of air bubbles

and deposits by a strong flushing of the line. After the water has been displaced in the specified time, the glass tube admitting the water is removed and the glass stopper quickly inserted in place to prevent exposure of the sample to air. Make certain that no air space is left between the stopper and water. The glass stopper should be ground to a point or cone to eliminate trapping of air.

The next step, adding the reagents, should proceed immediately. Remove the stopper from the sample bottle and add immediately 2 c.c. of manganous chloride and 2 c.c. of alkaline potassium iodide in the order mentioned and quickly replace the stopper. The pipettes used to deliver these reagents should extend to the bottom of the bottle, and the additions, made in sequence with individual pipettes, should be rapid. A short length of rubber tubing should be attached to the upper end of the pipettes to reduce the possibility of drawing the solution into the mouth. Do not expel solution by breath.

After the addition of the alkaline potassium iodide, replace the stopper, mix by shaking and permit the precipitate to settle, then add 2 c.c. of sulphuric acid and mix by shaking.

To this point, the procedure must be carried out in the field but after the acid has been added and the stopper replaced, the rest of the test shall be performed as soon as convenient, preferably within one hour.

Titrating Sample

Measure 250 c.c. of the sample and transfer it to a 300-c.c. porcelain casserole or if the volume of the sample bottles are previously determined the entire sample may be conveniently transferred and titrated.

Titrate the sample with 0.025 N sodium thiosulphate until the solution becomes a pale yellow color, then add 3 c.c. of the starch solution and titrate until the first disappearance of the blue color.

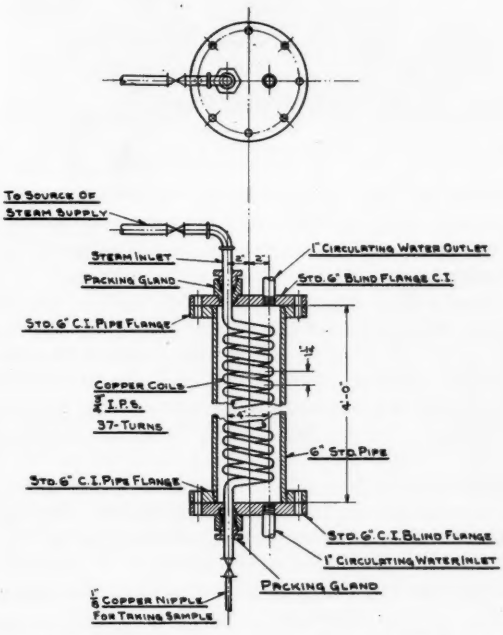


FIG. 1. DETAILS OF A COPPER COIL FOR COOLING SAMPLES

FIG. 2. SAMPLING BOTTLE WITH STOPPER GROUND TO A POINT. GLASS TUBE GOES TO BOTTOM OF BOTTLE SO AIR IS DISPLACED BY THE WATER

If the sample contains oxygen in excess of 0.5 c.c. per liter, the water will have a decided yellow color; if zero or only traces of oxygen, the water will not appear yellow. The starch solution should then be added and if any blue color appears, thiosulphate should be added until the blue color disappears. The difference between the initial and final readings of the burette will be the number of cubic centimeters of thiosulphate used, which is proportional to the amount of oxygen present.

Calculations

If 250 c.c. of water were titrated, the calculations will be as follows:

$$(1000 \div 250) \times (\text{c.c. of } 0.025 \text{ N. Thio.} \times 0.1395)$$

equals cubic centimeters of oxygen per liter standard condition, that is, 0 deg. c. and 750 mm. Express individual results to the second decimal place and report values below 0.03 as "trace."

When making this determination, the following notes may be helpful:

1. When the manganous chloride and alkaline

FIG. 3. APPARATUS AND REAGENTS WITH SETUP FOR TITRATING THE SOLUTION. SEPARATE PIPETTE EXTENDING TO BOTTOM OF BOTTLE USED FOR EACH REAGENT

potassium iodide are added, a white precipitate (manganese hydroxide) will be noticed.

2. If oxygen is present, a brown colored precipitate will be noticed which is manganous acid, depending upon the amount of oxygen present.

3. The addition of the sulphuric acid dissolves the brown precipitate and sets free an amount of iodine equivalent to the quantity of oxygen in the sample.

4. The solution at this time will be yellow in color; the depth of color depending upon the amount of oxygen present.

5. If oxygen is present and starch is added to the solution at this stage, the color will change to a deep green or blue color, depending upon the amount of iodine (oxygen) present.

With care, the above procedure will give reproducible results as low as 0.03 c.c. of oxygen per liter.

Details of Conowingo Voltage Regulators

REASONS FOR SELECTION. OPERATION ON SYSTEM AND METHOD OF CONNECTION. BY J. H. ASHBAUGH*

IN CHOOSING REGULATORS for Conowingo, consideration was given to the fact that the load on the station was to be very steady, since this is a base load station. The use of quick response excitation was decided upon after a thorough study of the transmission

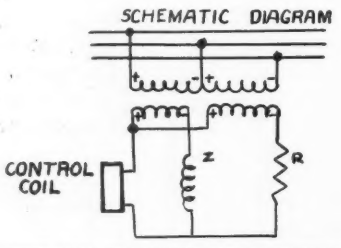


FIG. 1. POSITIVE PHASE SEQUENCE NETWORK USED AT CONOWINGO TO ENERGIZE CONTROL COIL OF REGULATORS

line demonstrated that it was necessary in order to obtain stability under transient conditions.

In generating stations which are of a base load character, the actual need for voltage regulators is small. The load variation is usually relatively minute, so a large portion of the time there is actually no work required from the regulators; however, during switching operations, storms, line faults or other transient conditions there is a demand for a voltage regulator that is quick in its action. The regulator must be capable of varying the exciter voltage over wide limits and in the minimum time. These occasions which necessitate voltage regulators are such a small part of the total time that it is highly desirable for a regulator to be static under steady load conditions.

At Conowingo, the regulators installed have all of the above mentioned attributes. They are simple to operate, rugged in construction, reliable and free from the ordinary maintenance required of most voltage regulators.

A vibrating voltage regulator controls the alternating current voltage by rapidly short-circuiting and inserting a resistance in the exciter field circuit. When it is desired to take a vibrating regulator out of service, the exciter field rheostat is turned towards the out position until vibration ceases. If it is left in this position and an additional load is put on the machine, lowering the a.c. voltage, the regulator will start vibrating again, maintaining normal voltage. It will cease vibration upon a further movement of the exciter rheostat towards the out position. The regulators at Conowingo work on this principle except, instead of having the operator move the rheostat, it is moved automatically under the command of the regulator.

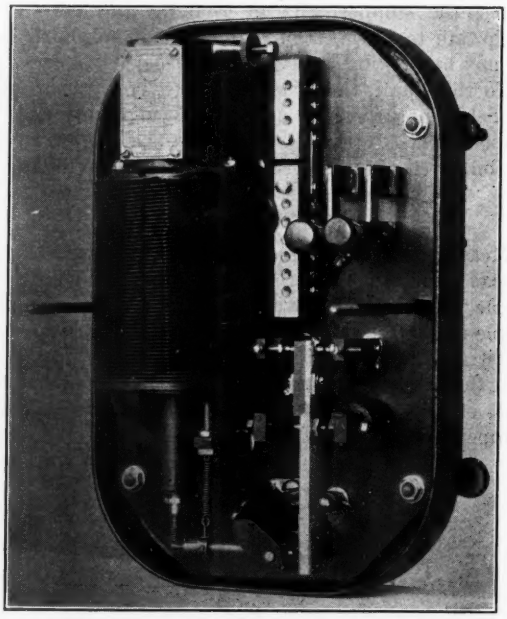


FIG. 2. CONTROL ELEMENT OF VOLTAGE REGULATOR

Assume that the regulator is in service and both the load and regulator are static. When an additional load comes on the unit, the regulator starts to vibrate, maintaining normal voltage. As the regulator vibrates the rheostat is automatically moved and the vibrations finally cease, the regulator being in a state of equilibrium.

When the load on the unit is reduced, the regulator inserts resistance in the exciter field circuit. The motor operated rheostat is also rotated towards the "in" position and the vibration finally ceases.

From the foregoing, it is evident that the speed or response of the regulator is independent of the rheostat speed. It has all of the quickness of response for which the vibrating regulator is noted, since it short

*Control engineer, Westinghouse Electric & Mfg. Co.

circuits the motor operated rheostat in a similar manner to the vibrating regulator.

When it is desired to cut the regulator into service on a machine, it is only necessary to turn one drum control switch. Likewise, to remove it from service, this same switch is turned to the off position and the machine is on hand control; therefore, the ease with which it can be placed into and removed from service gives this regulator a decided advantage.

The same type of regulators are used on the two small house service units; even during the construction period when the load fluctuation was rather frequent and severe due to operation of the cranes, the relatively long periods of rests, when the load is steady, makes for long life with a minimum of attention and maintenance.

On the main units, a positive phase sequence network is used so as to energize the control coil from all three phases, thus insuring proper operation of the regulator under line faults. When a regulator is energized from only one phase and a short circuit appears on one of the other phases, the voltage may rise on the regulated phase. This causes the regulator to reduce the excitation when in reality it should increase it for line stability. Figure 1 shows this network which consists of a reactance in one phase and a resistance in the other phase.

Ruggedness of the regulator is shown by a close examination of the control element Fig. 2. It is to be noted that no liquid dashpots are used. There is practically no attention required by this element. The outstanding features of the Conowingo regulators are ease of operation, simplicity, quickness of response, freedom from maintenance and reliability. They operate only when the condition demands it; thus, when there is no need for action, they are quiet.

Diesel Power Plants for Large City Buildings

ANALYSIS OF OPTIONAL METHODS OF POWERING LARGE BUILDINGS WITH A STUDY OF HOW THIS REQUIREMENT MAY BE MET BY DIESEL POWER PLANTS.* BY EDGAR J. KATES†

INHERENT CHARACTERISTICS of Diesel engines that make them particularly suited to large city building service are high economy even in small sizes and compactness. Even in units as small as 100-kw.

Table 1. Heat Balance of Diesel Engine.
(Showing importance of heat recovery)

	B.t.u. per bhp per hr	Per cent	Useful Per Cent	Heat Recoverable Btu per bhp per hr.
Brake work	2545	33	33	
Friction	680	9	—	
Jacket water heat	2100	27	27	2100
Exhaust gas heat	2200	28	11	880
Radiation, etc	255	3	—	
Total	7780	100	71	2980 or 4500 Btu per kw-hr.

capacity, the cost of fuel per kw-hr., based on 7 cent oil, is only 0.7 c. Of interest in connection with problems faced in the application of Diesel engines to large buildings are studies in reliability, maintenance cost, vibration and noise.

As an illustration of present reliability of Diesel engines, the statement is made that about one fifth of the country's oil engines are running in the pumping stations on oil pipe lines, which is a continuous service, 24 hr. a day, every day in the month and the load is large, averaging 87½ per cent of rating. Typical records of operation under these conditions show a dependability exceeding 99½ per cent. Records of engines that have been used in various commercial services for from 5 to 10 yr. show a cost of maintenance and repairs of 0.05 cents per rated hp-hr.

With proper selection of engine and proper manner of installation, all objectionable vibration may be avoided. Reduction in weight of moving parts, increase in stiffness of parts such as crankshafts, better mechanical balance and use of cork mats and of flexible connections in the piping are among the factors given which have eliminated objectionable vibration from modern Diesel engines.

Exhaust and air noises can be completely eliminated by the use of silencers and modern design has reduced considerably the noises due to valve motion through the exercise of more attention to cam shafts, reduction in weights of parts, better spring design and use of effective enclosures.

In applying Diesel engines to large buildings, full advantage should be taken of the ease with which waste

Table 2 Summary of Cost of Diesel Power

18 Story Office building, rentable area	235,000 sq. ft.
Annual consumption of electricity	1,165,400 kw-hrs.
Peak Load	350 kw.
Investment in 480 kw Diesel power plant	$77,000

Diesel Power Costs.	Dollars per Year	¢ per kw-hr
Fuel, 1,165,400 kw-hrs x .70 cent	$8,158	.70
Lubricating oil, $\frac{16000 \times 120 \times 1.5 \times .60}{2000}$	864	.07
Attendance, ($50 plus $40 plus $40) x 52	6,760	.59
Maintenance, 16000 x 120 x 1.5 x .05¢	1,440	.12
Gross operating cost	$17,222	1.48
Credit for street steam saved through recovery of Diesel heat, $\frac{1,165,400 \times 4.5 \times \$.80}{1000}$	4,190	.36
Net operating cost	$13,032	1.12
Overhead charges, 12% x $77000	9,240	.79
	$22,272	1.91

Comparison with Cost of Purchased Current.

	Dollars per Year	¢ per kw-hr.
1,165,400 kw-hrs at existing wholesale rate	$32,933	2.83
1,165,400 kw-hrs at $.002 coal surcharge	2,331	.20
Attendance, and overhead charges on investment disregarded		
	$35,264	3.03
Net saving with Diesel power	$12,992	1.12
Net return on investment (besides 12% overhead charges)	16.8%	
Operating saving with Diesel power	$22,232	1.91
Time to retire Diesel investment	Under 4 years.	

*Abstract of paper presented at the April 24, 1929 meeting of the Metropolitan Section of the American Society of Mechanical Engineers.

†Consulting Engineer, New York City.

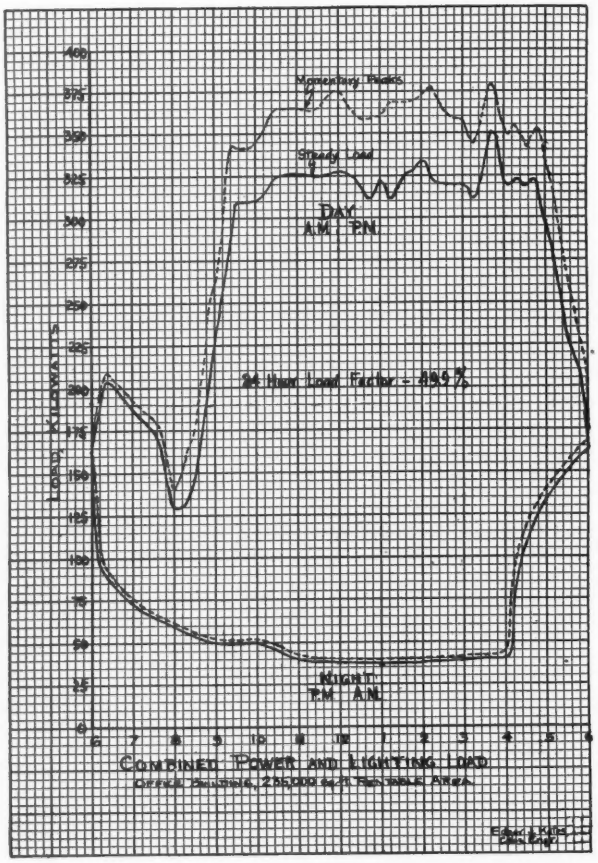


FIG. 1. DAILY COMBINED POWER AND LIGHTING LOAD ILLUSTRATING CHARACTERISTIC STEADINESS

heat of such may be regained. A typical heat balance is shown in Table 1. It will be noted that the jacket water heat, amounting to 27 per cent of the heat in the fuel, is almost as much as the heat that is turned into work. This jacket water heat can be utilized directly to warm water. About 40 per cent of the exhaust heat can be recovered by passing it through a simple exchanger of the shell and tube type. By thus utilizing the jacket and exhaust heat, a total recovery of about 38 per cent may be obtained. This corresponds to about 4500 B.t.u. per kw-hr.

Required Attendance Gradually Being Reduced

Amount of attendance required in Diesel power plants is being gradually reduced both because the engines themselves are being made more simple and more rugged and because of the introduction of various forms of automatic control, thus permitting one operator to attend a large number of engines or, in smaller plants, to occupy himself with other useful duties. Such automatic controls also lead to improved operating conditions.

All buildings require heat as well as power and it is necessary, therefore, to consider heat requirements along with power needs. Buildings can be served by many possible combinations, such as

1. Diesels for power; steam boilers for heat only.
2. Steam boilers and steam engines for heat and power.
3. Diesels for power; street steam for heat only.
4. Street steam for heat and power.
5. Steam boilers with steam engines and Diesel engines in various proportions.

Combination Plants Have Advantages

The simplest scheme is to use Diesel engines for power, and street steam for heat required beyond that recoverable from the Diesels. This scheme is particularly applicable in certain sections of down-town New York where street steam is available and the basement space is too limited or too valuable for a boiler plant. In this scheme the following attractive features of Diesel power, besides that of low cost, become apparent:

1. No labor troubles with firemen. Any good steam engineer can learn to run a modern Diesel engine. (A licensed engineer is not required by law.)
2. Only a small amount of fuel needs to be transported through the streets. One 1500-gal. tank wagon will deliver fuel for 15,000 kw-hr. or enough to run a 350-kw. plant for a week.
3. No ash to be removed.
4. There is no smoke.
5. The Diesel power plant is very compact and can be fitted into a surprisingly small space.
6. All of the plant equipment can be easily installed. The engines themselves can be dis-assembled into small parts so as to permit them to pass through the usual freight elevator shaft.
7. The exhaust gases can be easily disposed of and their pipes are very much smaller than the stack of an equivalent steam plant. A moderate increase in back pressure caused by a long exhaust pipe is not detri-

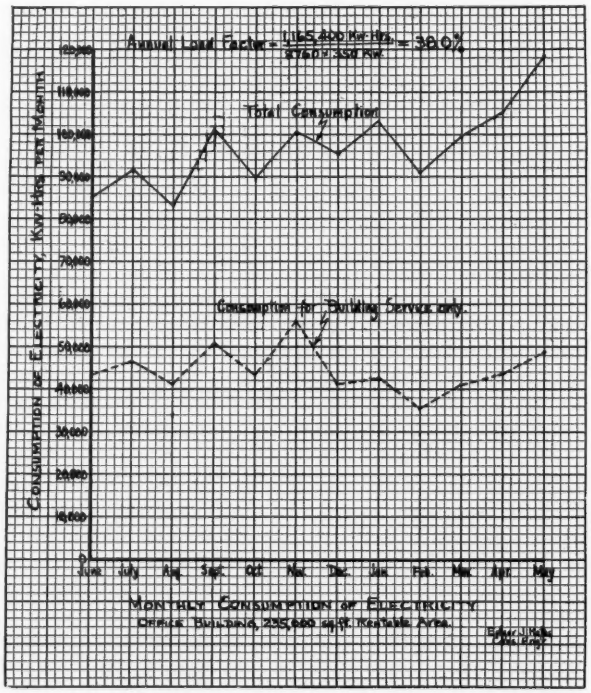

Annual Load Factor = 1,185,400 Kw-Hrs. / 8760 x 350 Kw = 38.6 %
Total Consumption
Consumption for Building Service only
CONSUMPTION OF ELECTRICITY, KW-HRS. PER MONTH
June July Aug. Sept. Oct. Nov. Dec. Jan. Feb. Mar. Apr. May
MONTHLY CONSUMPTION OF ELECTRICITY
OFFICE BUILDING 285,000 sq. ft. RENTABLE AREA

FIG. 2. CONSUMPTION OF ELECTRICITY BY MONTHS FOR AN ENTIRE YEAR SHOWING COMPARATIVE UNIFORMITY

mental to a four-cycle engine or to a two-cycle engine with positive scavenging.

Power Study for Office Building

Based upon an 18-story office building on Wall Street, New York, the following power study was made. Figure 1 shows the combined power and lighting load which is quite uniform throughout the business day. The load factor over the entire 24-hr. is about 50 per cent. Figure 2 indicates that there are no significant variations of electrical consumption due to seasonal changes.

Fixed charges were estimated at 12 per cent, which would include interest at 6 per cent and depreciation, based on a 15-yr. life, requiring a sinking fund of 4.3 per cent. The factor of obsolescence may be disregarded with Diesel engines, as the efficiency of the latest engines is practically the same as that of the earliest models. It would seem therefore that, including insurance and taxes, 12 per cent total fixed charges on the entire investment would be ample.

Lubrication efficiency may be assumed safely at 2000 rated hp-hr. per gal. and the cost of Diesel lubricating oil at 60 cents per gal. The operating staff of the plant, which comprised four 120-kw. Diesel generating units, would consist of a chief engineer at $50 per week and two assistant engineers at $40 per week.

On the above basis, the cost of electric current generated is summarized in Table I. The net operating cost for producing 1,165,400 kw-hr. per yr. is $13,032 or 1.12 cents per kw-hr. Adding overhead charges of 12 per cent on the entire investment, the total annual cost is $22,272, or 1.91 cents per kw-hr. Purchased power in New York City would amount to 3.03 cents per kw-hr.

Use of Exhaust Steam Favors Steam Plant

When heating of a building is done by its own boilers, the engineering study becomes broader and more complex. High-pressure boilers cost little more than those of the low-pressure type and the cost of producing steam at 150 lb. is little more than that at low pressure; consequently power produced by steam engines, when all of the exhaust steam is utilized in the heating system, is cheap indeed. In such cases, the amount of fuel burned to produce one kw-hr. is less than ½ lb. But when the exhaust steam is wasted to the atmosphere or when it is condensed, steam power costs much more than Diesel power. This indicates that the most economical type of private power plant would be a combination of steam and Diesel power in some definite proportion depending upon the local conditions. Studies of actual cases confirm this.

In studying power application for a loft building, the location assumed was down-town New York and the building was assumed to cover an entire block and have a volume of 14,000,000 cu. ft. The heating load was taken as 80,000 sq. ft. requiring 25,000 lb. low-pressure steam per hour with an annual consumption of 33,000,000 lb. Demand for process steam was taken as 25,000,000 lb. live steam per year.

Lighting load would reach a maximum of 550 kw. with an annual total of 1,075,000 kw-hr. Service load will consume 330,000 kw-hr. and the annual power requirement for manufacturing purposes is estimated at 1,175,000 kw-hr. The consumption of electricity in the entire building thus totals 4,200,000 kw-hr. per yr. of which 1,750,000 is chargeable to tenants and 2,450,000 to the owners.

Optional studies of costs and economies were made for the following plant schemes:

A. Three 500-kw., and one 200-kw. uniflow engine generating units. Three oil-fired boilers of 700 to 750 rated hp. each. All necessary boiler plant and engine-room auxiliaries, pumps, piping and instruments.

B. Same plant as A; except that one of the 500-kw.

TABLE No. 3 Initial Cost of Various Schemes
(omitting items common to all)

Item	Scheme A	Scheme B	Scheme C	Scheme D	Scheme E
	Boilers, 3-750H.P.	3-750 H.P.	3-500 H.P.	3-400 H.P.	3-400 H.P.
	1-Power 3-500 Kw. & 1-200 Kw.	2-500 Kw. & 1-200 Kw.	2-500 Kw.	1-500 Kw. & 1-200 Kw.	None
	Diesel Power None	1-500 Kw.	1-500 Kw. & 1-200 Kw.	2-500 Kw.	None
Boiler Plant & Auxiliaries	$ 98,000	$ 98,000	$ 82,000	$ 68,000	$ 68,000
Steam Power Plant & Aux.	130,000	94,500	75,000	57,000	———
Diesel Power Plant & Aux.	———	70,000	98,500	139,000	———
Switch board Wiring, etc.	15,000	15,000	15,000	15,000	———
Total	$ 243,000	$ 277,500	$ 270,500	$ 279,000	$ 68,000
Less Scheme E	68,000	68,000	68,000	68,000	
Net	$ 175,000	$ 209,500	$ 202,500	$ 211,000	

TABLE No. 4
Operating Labor (Oil-Burning).

Item	Scheme A	Scheme B	Scheme C	Scheme D	Scheme E
Chief Engineer	$5000	$5000	5000	5000	$3,500
Assistant Engineer	6000	6000	6000	6000	$2,500
Firemen	5000	5000	5000	5000	5,000
Oilers	3000	3000	3000	3000	———
Electricians	5000	5000	5000	5000	———
Total	24,000	24,000	24,000	24,000	11,000
Less Item E	11,000	11,000	11,000	———	———
Net	13,000	13,000	13,000	13,000	———

TABLE No. 5
Annual Steam & Fuel Consumption

Item	Scheme A	Scheme B	Scheme C	Scheme D	Scheme E
Current generated by Steam	4,200,000 Kw-Hrs.	2,700,000 Kw-Hrs.	2,500,000 Kw-Hrs.	1,900,000 Kw-Hrs.	———
Steam for Engines	147,000,000 Lbs.	93,000,000 Lbs.	74,000,000 Lbs.	67,000,000 Lbs.	———
L. P. Make-up Steam	———	———	5,000,000 "	7,000,000 "	33,000,000 Lbs.
Tenant Live Steam	23,000,000 Lbs.	23,000,000 "	25,000,000 "	25,000,000 "	25,000,000 "
Auxiliary Steam	6,000,000 Lbs.	6,000,000 "	5,000,000 "	4,000,000 "	4,000,000 "
Pipe Losses	3,000,000 Lbs.	3,000,000 "	4,000,000 "	3,000,000 "	2,000,000 "
Total Steam	183,000,000 Lbs.	131,000,000 Lbs.	113,000,000 Lbs.	106,000,000 Lbs.	64,000,000 Lbs.
Boiler Fuel Oil	1,830,000 gals.	1,310,000 gals.	1,130,000 gals.	1,060,000 gals.	640,000 gals.
Current generated by Diesels	———	1,500,000 Kw-Hrs.	2,100,000 Kw-Hrs.	2,300,000 Kw-Hrs.	———
Diesel Oil	———	150,000 gals.	210,000 gals.	230,000 gals.	———

TABLE No. 6 Total Annual Charges
(In excess of plant and labor for Heating and Steam service)

Item	Scheme A	Scheme B	Scheme C	Scheme D	Scheme E	
	Extra Initial Cost $175,000	Extra Initial Cost $209,500	Extra Initial Cost $202,500	Extra Initial Cost $211,000	Purchasing Owner's Current only	Purchasing all Current
12% on Excess Invest.	$ 21,000	$ 25,200	$ 24,300	$ 25,300		
Excess Labor	13,000	13,000	13,000	13,000		
Insurance on Labor	260	260	260	260		
Steam Repairs & Lubrication	6,000	6,000	4,500	4,000	$ 2,000	$ 2,000
Oil Eng. Repairs & Lubrication	———	2,500	3,500	4,200	———	———
Boiler Fuel Oil @ 4¢	73,000	52,500	45,200	42,500	27,000	27,000
Diesel Fuel Oil @ 7¢	———	10,500	14,700	16,100	———	———
Owner's Current Only	———	———	———	———	63,500	———
All Current	———	———	———	———	———	98,500
	$ 113,260	$ 109,960	$ 105,460	$ 105,360	$ 92,500	$ 127,500

TABLE No. 7 Revenue from tenants for Plant Services

Tenant Steam – 23,000,000 Lbs. @ 75¢ per M		$ 13,000
Tenant Current – 1,780,000 kw-hrs. @ 6¢ per		105,000
	Total	$ 124,000

TABLE No. 8 Comparison of Private Plant Schemes & Purchased Currents

Item	Scheme A	Scheme C	Scheme E	
	Extra Initial Cost $ 175,000	Extra Initial Cost $ 202,500	Purchasing Owner's Current only	Purchasing All Current and Sub-metering to Tenants
Tot charges for Power incl. overhead	$ 113,260	$ 105,460	$ 92,500	$ 127,500
Revenue from Tenants	124,000	124,000	19,000	124,000
Net Profit to Owners	$ 10,740	18,540	———	———
Net Loss to Owners	———	———	$ 73,500	$ 2,500

Jaros & Baum
E. J. Kates
Associated Engineers

units is to be a Diesel engine generating unit, including foundation, oil-tanks, muffler, auxiliaries and piping.

C. Two 500-kw. uniflow engines, one 500-kw. Diesel and one 200-kw. Diesel. Three 500-hp. boilers. All auxiliaries.

D. One 500-kw. and one 200-kw. uniflow engine, two 500-kw. Diesels. Three 400-hp. boilers. All auxiliaries.

E. No generating equipment (current to be purchased). Three 400-hp. high-pressure boilers for supplying tenants with high and low-pressure steam. Boiler plant auxiliaries.

Analysis of Costs

Table 3 gives an estimate of the initial cost of each scheme, omitting, for ease of comparison, those items that are common to all. The all-steam power plant is the cheapest of the private plants. It costs $175,000 more than the heating plant without power generation. Scheme C, with two 500-kw. steam units, one 500-kw. Diesel and one 200-kw. Diesel, is the cheapest combination plant, costing $202,500 more than the non-power generating plant.

Table 4 gives the estimated labor cost for each of the several schemes. It is based upon using oil for boiler fuel and upon a liberal wage scale which is justified by the cost of the equipment to be operated. The annual labor cost for operating any one of the various generating schemes is $13,000 more than under the condition in which current is purchased.

Table 5 is an analysis of each scheme showing (a) the amount of current generated by steam and by Diesels, (b) the total high pressure steam requirements and (c) the amount of boiler fuel oil and Diesel fuel oil consumed. In all the generating schemes, the live steam used by the steam engines greatly exceeds the quantity of low-pressure steam needed for heating, (33,000,000 lb. per year) but the demands for power and heat not being wholly coincident, schemes C and D require a certain amount of live steam to be fed to the heating system through reducing valves.

In Table 6 the data of the preceding tables is converted into dollars and cents. Here are shown the various elements of the annual and fixed charges for the four generating schemes, compared to the purchase of all current under scheme E. Under scheme E two plans are shown, one, that of purchasing only the owners' current (the tenants purchasing their own current direct from the public utility), the other plan being for the owners to purchase at wholesale rates all of the current used in the building and to resell part of it to the tenants at the usual retail rate, i. e., to sub-meter it. (The legality of the latter plan is now being questioned before the Public Service Commission of New York and several other States.)

Among the generating schemes, "A" (all steam) is cheapest to install but most expensive in annual costs, while "C" (1000 kw. in steam and 700 kw. in Diesels) is the cheapest to install of the combination plants and practically the cheapest to operate. Schemes "B" and "D" are therefore discarded.

Before comparing the private plant schemes with purchased current, it is necessary to take account of the revenue obtained from the tenants for the current furnished them by the private plant. This is shown in Table 7, the electric revenue being $105,000 per year and the high pressure steam, $19,000.

Final Cost Comparison

The final comparison is given in Table 8. Both of the private plant schemes show a net profit to the owners, in addition to supplying all the building services, incumbent upon the owners. Of the two, Scheme C is the better, as it shows $8000 greater profit per year on a $28,000 greater investment, (besides paying the fixed charges on the increased investment).

Comparing Scheme C with E, assuming that sub-metering will be permitted, the first shows an annual profit of $18,500 and the second an annual loss of $2500. Thus Scheme C shows an annual saving of $21,000 net after charging off 12 per cent fixed charges on an investment of about $200,000. Another way of looking at this is not to figure fixed charges as such; in that case, the savings in the operation of Scheme C, as compared with Scheme E, are approximately $45,000 per year, enough to retire the increased investment in about 4½ yr. and yield this much net gain each year thereafter.

Of course, if sub-metering under Scheme E should not be permitted, then Scheme C becomes very much more attractive. Its net annual return in that case becomes $92,000, or, including fixed charges, $116,000; enough to retire the investment in less than 2 yr. and thereafter yield a net annual return of over 55 per cent.

Use of Diesel engines in large city buildings has so many attractive features, besides the great financial incentive, that careful study of their application is well justified.

San Francisco industrial plants, after August 15, will be assured natural gas at 25 cents per thousand cubic feet, it is stated, when the Pacific Gas & Electric Co. completes the 247-mi. pipeline by which it is bringing natural gas to San Francisco from the Buttonwillow and Kettleman Hill fields, southwest of Fresno. Rate schedule is to be presented for the approval of the California Railroad Commission at an early date. To specially large consumers, it was stated that the rate probably would be lower than 25 cents. It will be allowed, although only in conjunction with "shut-off" restrictions similar to those now in effect in Los Angeles.

On the Panoche pass unit, work is proceeding from both ends. A 16-in. main will be led from the Buttonwillow field to Kettleman Hills, California's newest and perhaps largest gas field. From Kettleman Hills, the main will be 22 in. in diameter to a point near Mendota, Fresno county, with a 20-in. pipe from there to Milpitas. At Milpitas a meter station will be erected and from it two mains will be laid, one into San Francisco and the other to the East Bay Cities of Oakland, Alameda and Berkeley.

Bay cities consumers will be served a mixture of natural and manufactured gas of 700 B.t.u., as compared with 550 B.t.u. in the present artificial gas.

Public Service Co.'s new building, Cass and Ottawa Sts., Joliet, Ill., headquarters for the Public Service Co. and the Western United Gas and Electric Co., was formally opened recently.

Building a Power Plant from Its Own Savings

BY AN INGENIOUS METHOD of financing, the Gates Rubber Co., of Denver, Colo., states that it was able last year to build a new power plant to serve its large and growing factories, without making any investment of capital. Desirability of a new plant was felt when the local public utility company that had been supplying electric power to the factory decided to increase its rates. When this occurred, an analysis was made of the company's demands for power and process steam; a large quantity of such steam had been previously supplied by a boiler plant. The analysis showed that a combination of these two services would be sound economics. Accordingly, the new plant shown in the illustration was designed for a total capacity of 2500-kw. in three turbine-generator units, steam for which is furnished at 400 lb. pressure, 250 deg. superheat by two 6130-sq. ft. cross-drum, water-tube boilers.

Cost of the plant was borne entirely by bonds issued by a subsidiary company, the Gates Power Co., formed for the purpose of building the power plant. These bonds were in no wise an obligation against the Gates Rubber Co. The bonds are being retired from the earnings, which are set out in such a way that the same amount of money is paid to the Gates Power Co. that would have been paid to the public utility if the new plant had not been built. It is calculated by the company that the saving in making power and steam in the new plant, as compared with the amount that would have been spent if the company had purchased power under the rates required, will be over $100,000 a year, which should pay for the plant in less than 5 yr.

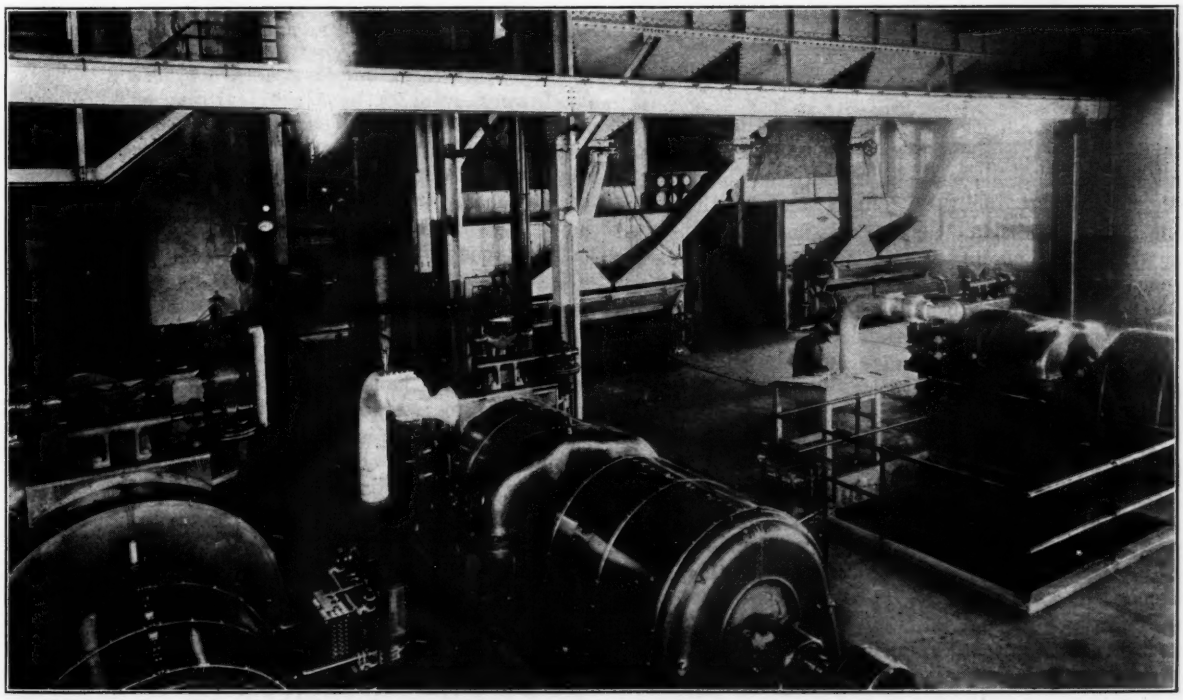
Thus, it is explained, the plant will stand as an asset to the company in a short time, without representing any capital investment.

One of the interesting features of the installation is that there is no division between boiler and turbine room, so that the plant may be operated with a minimum of labor. This arrangement is shown in the photograph. The plant was designed by Wood & Weber, Inc., who supervised its construction. Carl R. Ahlquist, chief engineer of Gates Rubber Co., built the plant in accordance with their plans.

One condition especially favorable to the new plant was the supply of good water from a well previously drilled to supply the entire factory; this well can supply 1,000,000 gal. a day. It was necessary only to install a water softening system of 26,000 lb. per hr. capacity for makeup water and process water.

Two boilers of 6130 sq. ft. heating surface each, with superheaters, are fired as shown by coal burned on chain grate stokers, motors of which are controlled by regulators. Feedwater regulators, internal steam purifiers and all necessary accessories are provided, together with a complete installation of instruments. Each boiler has a 2376-sq. ft. steel tube economizer and a 46,000-c.f.m. induced-draft fan driven by a slip ring motor. Complete system of coal and ash handling machinery has capacity of 35 t. an hr. Two 7-stage, 125-g.p.m., 410-lb.-head centrifugal pumps supply feedwater, one driven by steam turbine and one by motor.

Two turbine-generators, each of 1000 kw. capacity are operated condensing, the condensers being 1500-sq. ft. units. The third 500-kw. turbine-generator exhausts to the processes at 150 lb. gage and its power output depends on the amount of process steam used. A cooling tower is installed to cool condenser circulating water.



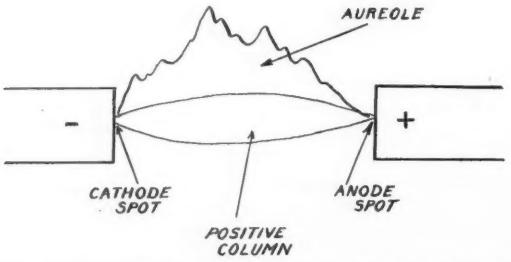
THREE TURBINE-GENERATORS AND TWO BOILERS IN SAME ROOM FOR CONVENIENCE OF OPERATION

Electricity---What It Is and How It Acts*

PART XXIV. THEORIES OF THE ELECTRIC ARC. CONDITIONS EXISTING IN DIFFERENT PARTS OF THE ARC. BY A. W. KRAMER

HAVING AN IDEA OF how a thing acts and actually understanding it are two different things. Often, we think we understand a certain phenomenon, yet when pressed for a detailed explanation, to our own surprise we find that we know very little about it.

So it has been with the theory of the electric arc. It was known for a long time that arc phenomena were due to the presence of electrons in the arc space but when it became necessary to explain just how these free electrons were produced, electric arc phenomena were not quite so simple as they were thought to be.



THE PHYSICAL STRUCTURE OF THE ELECTRIC ARC

The arc consists of four parts as shown. The flame like portion extending upward from the positive column is due to combustion.

As long as the current density in the arc was low or when the discharge took place as a glow or brush, the electrons could be accounted for simply on the basis of ionization by collision as explained in the preceding article. But the true arc, the arc we are familiar with in ordinary electrical work, presents features which are quite different from those exhibited in the glow or even in the disruptive discharge. The principal characteristic of the arc is its high current density which means, of course, a high electron density.

It is this high electron density that has been the stumbling block. Calculations show that electron densities in actual arcs come out entirely too high, to be able to account for them purely on the theory of ionization by collision. Certain arcs have been observed in which the current density at the cathode was as much as 30,000 amp. per sq. cm. The voltage gradient in arcs of this kind is usually very low and calculations show that under such low gradients electrons could not gain sufficient velocity to ionize sufficient atoms to produce such high electron densities. Then, where do they come from?

Many have investigated this question and various theories have been proposed but none have been positively accepted as being correct. In this country, Professor K. T. Compton has done a great deal of excellent work on the arc and his theories have been more generally accepted perhaps than those of any other single investigator.

Before we discuss the various theories of the arc that have been proposed it will be well to consider an actual arc to learn something of its physical structure.

*All rights reserved.

STRUCTURE OF THE ELECTRIC ARC

For purposes of study, an electric arc may be considered as being made up of four parts as depicted in the diagram, Fig. 1. By looking at an arc through a blue or dark glass, it will be seen that the arc issues from a bright spot in the cathode and terminates on another bright spot on the anode. These may be called the cathode and anode spots respectively. The central portion of the arc is quite clearly defined—it extends from electrode to electrode in the form of an intensely bright core, which has come to be known as the positive column. Finally, there is seen an outer part of the arc which is a sort of a flame rising upward. According to Dr. Slepian, the Germans call this flame the aureole.

This aureole, from all investigations, seems to be nothing more than a flame due to the combustion of vapors in the arc, for if steps are taken to exclude all oxygen, the aureole disappears. While the aureole is the result of the heat of the arc, rather than a fundamental factor in its formation, it plays an important part in maintaining the arc, once it has been formed, particularly in the case of an alternating current arc. In the alternating current arc, where the potential across the arc passes through zero a number of times per second, there is a tendency for the arc to be deionized at the time of zero potential and if it were not for the presence of the burning gases in the aureole, the arc might fail to restrike when the potential rose again. Where the aureole is present, however, this does not occur, because the chemical combinations of the combustible gases with the oxygen molecules is much slower than the processes of ionization and deionization and as long as these gases keep burning, they provide a source of ionization, which serves to reignite the arc after the voltage has passed through zero and built up again. This reignition of the arc after each passage through zero is responsible for the fabric appearance of a long high voltage alternating current arc when shown on a photograph. See Fig. 4.

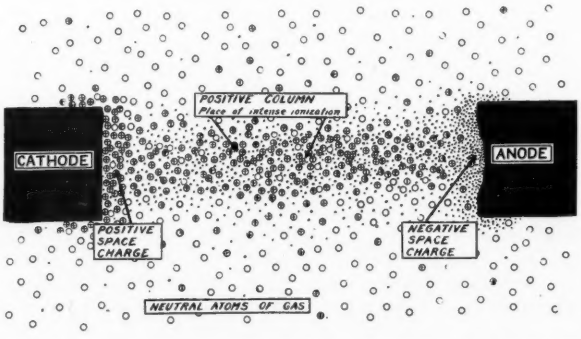


FIG. 2. DIAGRAM SHOWING THE CONDITIONS IN A HEAVY DIRECT-CURRENT ELECTRIC ARC

This diagram is necessarily very crude but it attempts to show the manner in which the space charges are located.

Thus, while the aureole is important in maintaining the arc after it has once formed, it may be considered as a result rather than a cause, and for this reason we need not give it further consideration here.

Conditions at the Cathode

Perhaps the most baffling problem regarding the arc is the explanation of the high current density occurring at the cathode spot. Where do the electrons which make up this current come from?

The cathode, we have seen, is surrounded by a space charge of positive ions but these ions are insufficient in number to account for the high current densities at the cathode observed in practice. This positive space charge,

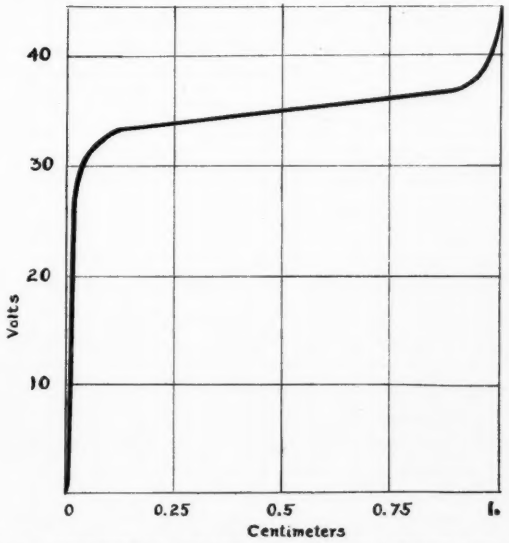


FIG. 3. POTENTIAL GRADIENT CURVE ACROSS AN ARC
Because of the positive space charge at the cathode practically all of the potential drop is adjacent to the cathode.

it will be recalled, was created when the potential was first applied and the electrons moved away toward the anode. The positive ions tend to move toward the cathode but being a thousand times more massive than the electrons, they move with only a thousandth part of the speed of the electrons; hence their effect in conducting the arc current is small.

The explanation of the action at the cathode spot, therefore, must be explained in terms of electrons and all lines of evidence indicate that these electrons are in some way emitted from the cathode itself.

To produce such emission, only two processes seem capable of supplying an electron emission from the cathode in sufficient amount; first, thermionic emission, due to the heating of the cathode and, second, the actual pulling of electrons from the cathode by the electric field, or a combination of both. J. J. Thomson and Stark first suggested the former theory and Irving Langmuir the latter one.

Offhand, the thermionic emission theory is logical for the temperature of the cathode spot in most cases is high enough for thermionic emission; in fact, actual measurements of the temperatures of a number of different arcs indicate that such thermionic emission actually occurs, particularly where electrodes having high melting points are used. The measurement of the temperature of the cathode spot is a difficult matter, owing to its small size and its frequent rapid motion, yet it has been done with varying success. In the case of carbon or tungsten arcs, the temperatures found checked very well with the current densities for arcs between these materials. With metals of lower melting point, however, where the temperature of the cathode spot is only slightly over the boiling point, the thermionic emission theory does not hold so well, for even when such metals reach the boiling point, the temperature is still too low for intense thermionic emission.

Langmuir's Theory

In such cases, the theory advanced by Langmuir seems to offer a way out of the difficulty. According to this theory, the electrons are actually pulled out of the metallic cathode by the electric field. Naturally, this could only be done if the field was exceedingly intense but Langmuir has shown that, as the result of the large space charge at the cathode, the field there actually reaches an enormous intensity—in excess of a

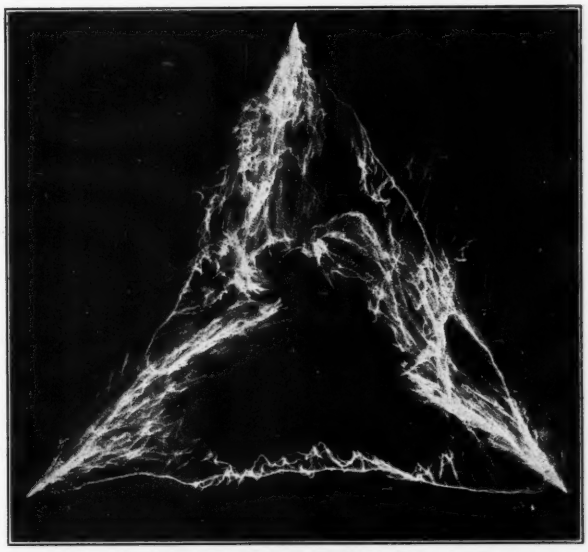


FIG. 4. A HIGH VOLTAGE ALTERNATING CURRENT ARC
This is a 3-phase arc, nine feet between points at 1,000,000 v. An arc of this type because of the alternating potential tends to extinguish each time the voltage passes through zero. Because of the high temperature of the surrounding gases, the gases in the path of the arc remain ionized which permits the arc to be restruck as the voltage builds up. The arc is restruck along the path which still remains ionized. Due to air currents this path is in slow lateral motion, which results in the fabric like pattern noted in the above photograph.

million volts per centimeter. Under such fields, electrons would be drawn out of the cold metal.

That such a pulling out of electrons from the metal constituting the cathode actually occurs is borne out by certain experiments by Stoltz in Germany and by Dr. Slepian in this country. In these experiments, by means of a magnetic field, an arc was caused to move around on a metal ring so rapidly that so far as observation was concerned the cathode remained practically cold. Dr. Slepian[1] caused an arc of 20,000 amp. to move on a copper surface with great speed, and upon examining the face of the electrode found a little oxidation but no burning or melting whatsoever. These ex-

[1]Theory of the Electric Arc. Journal of the Western Soc. of Eng. April, 1928.

periments seem to eliminate the necessity for thermionic emission.

While it is probable that in this case there was no thermionic emission, on the other hand, as Prof. Compton has pointed out, there are many cases where melting and fusing of the electrodes does occur and in such cases it is certain that thermionic emission occurs with marked effect. In such cases, also, it is probable that the emission of electrons from the cathodes is aided by the pulling-out effect of the electric field, that is, the emission current is due to a combination of both causes.

While it may seem unreasonable at first thought to assume that a potential gradient high enough to pull electrons out of the cold metal could exist at the cathode,

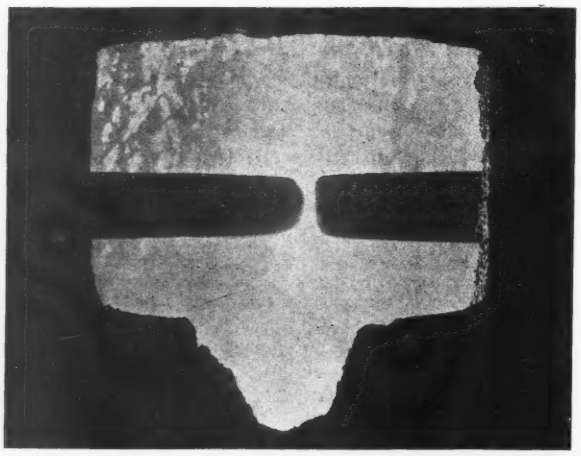


FIG. 5. THE ELECTRIC ARC IS THE HOTTEST PLACE WE KNOW OF ON EARTH

This 2500-amp., 100 v. arc between 4-in. graphite electrodes in a brass melting furnace attains a temperature of within 40 per cent of that in the sun.

it can be easily demonstrated mathematically[2] that such an intense field may exist. This high potential gradient is due, directly to the positive space charge surrounding the cathode.

In the preceding article[3] it was shown that a large portion of the total voltage drop existing across a highly ionized gas space is concentrated in the space immediately adjacent to the cathode. There is, of course, also a space charge at the anode and this is usually negative (although it may be positive) but its value is considerably less than that of the positive space charge due to the greater mobility of the electrons. The positive ions are ponderous, compared to the electrons and their speed (toward the cathode) is only a thousandth part of that of the negative ions or electrons. For this reason, their power of ionizing atoms near the cathode is almost negligible and, as a consequence, the space immediately adjacent to the cathode contains a great excess of positive ions. Since this layer (if we may call it so) of positive ions is located extremely close to the cathode, it is evident that an extremely intense field of force will be set up between the cathode and the positive space charge. From our study of the electric field[4] we know that the force varies inversely as the square of the distance between charges, hence, if, as in this case, the distance between charges is of the order of molecular spacing, the potential gradient may attain values of millions of volts per centimeter. Such gradients would suffice actually to pull electrons out of cold metal electrodes in such quantities as to be able to account for the high electron densities found in the electric arc.

Thus it is probable, in most cases, that the current at the cathode is due to two actions, thermionic emission and the pulling out effect of the field, although neither of these theories has been definitely proved. The thermionic theory alone, while it may suffice in some cases to account for the arc current, in other instances falls down.

One other theory has been proposed, this by Dr. Slepian.[5] In this he assumes that the current is carried not by electrons coming from the cathode but by positive ions coming from the highly ionized gas next to the cathode. Because of the extremely high energy concentration, a thin layer of gas next to the cathode, it is possible, is raised to a very high temperature—up to 10,000 deg. C. At this temperature, the thermal ionization of the gas would be almost complete. With such a high degree of ionization, it can be demonstrated mathematically that the positive ions are able to carry the required current density.

One word about thermal ionization; this is really a special case of ionization by collision. We have seen that as the temperature of a body, particularly a gas, is raised the molecules and atoms are invested with a greater amount of kinetic energy and as a consequence move about more energetically. The free electrons in such a body, under these conditions, also acquire more energy and as their velocity increases, the impacts of their collisions with atoms become more violent. It can be imagined that if the temperature of the body is raised high enough, the free electrons will acquire speed enough to begin to ionize by collision. Thus, this type of ionization, which can occur only at extremely high temperatures, is known as thermal ionization.

This is about as much as is known today about the conditions at the cathode of the electric arc. Conditions in the other parts of the arc, at the positive column and at the anode are more easily accounted for.

Conditions in the Positive Column

In the positive column, a combination of actions probably takes place. The positive column is characterized by high conductivity for in heavy direct-current arcs the current density may be many thousands of amperes per sq. cm. while the voltage gradient may be as low as 20 v. per in. This part of the arc, therefore, is the seat of intense ionization.

At first thought, it might appear as though this ionization might be due to collision but with a voltage gradient of only 20 v. per in., such intense ionization as is actually observed would be impossible. Compton suggests that much of it is thermal ionization and while this is true no doubt in the case of high temperature arcs such as the carbon or tungsten arc thermal ionization certainly plays no role in maintaining the mercury arc. Other factors exist, however, such as ultra violet radiation and since the arc is the seat of intense ultra radiation, this may be responsible for a large part of the ionization in the positive column, particularly in

[2]K. T. Compton, The Electric Arc. A.I.E.E. Transactions, 1927.

[3]Part XXIII May 1 issue, p. 525.

[4]Part VI, August 1, 1928, issue, p. 825.

[5]In discussion of K. T. Compton's paper, The Electric Arc. A.I.E.E. Proceedings, 1927. P. 879.

the mercury arc. It is quite evident, however, that there is no one cause of the ionization; it is the result of a combination of causes.

We have now considered the conditions at three parts of the arc, first, in the aureole, second, at the cathode and third, in the positive column. Only those at the anode remain to be discussed.

The current at the anode is due to the negative space charge set up near the anode when the positive ions move away toward the cathode. A high potential gradient is thus established, resulting in a steady movement of electrons toward the anode. This movement of electrons to the anode is more than sufficient to account for the high current densities found in heavy current arcs.

Since the arc is the seat of violent interchange of energy between atomic systems, it is naturally characterized by a rise in temperature; in fact, in the arc, we have the highest temperature found on earth.

Ever since the carbon arc was first used as an illuminant, it was known that practically all of the light was emitted from the incandescent crater of the positive electrode, that is, the anode. This fact is significant when the conditions at the anode discussed above are considered. The extremely high temperature found at the anode is due to the thousands of billions of high speed electrons impinging on the anode. Each electron is endowed with a certain amount of kinetic energy and as it strikes the anode, this kinetic energy is released and appears as heat and light.

This brings to a close our purely analytical study of the mechanism of the electric arc. In spite of its apparent simplicity, it will be evident that the arc is an extremely complex electrical phenomenon and one not easily understood. There are many other interesting facts about the arc and its application which can be explained on the basis of the electron theory and some of these will be considered in the next article.

Making Polyphase Meter Connections

RELATION OF POWER FACTOR TO WATTMETER CONNECTIONS. METHODS OF CHECKING AND PRINCIPLES INVOLVED. BY E. J. MORRISSEY*

NECESSITY of proper meter connections is obvious. We all know that with single phase meters properly connected on a three phase circuit and both rotating forward, that the power factor is above 50 per cent. The sum of the output is the arithmetical sum of the two meters, whereas, with proper connections and one of the meters rotating backwards, the power factor is below 50 per cent, the sum of the output being the algebraical sum of the two meters.

Why? and is there any difference in using two single phase meters in preference to a polyphase meter?

There is no difference in using two single-phase meters in preference to a polyphase meter output to register 3 phase power. A polyphase instrument is the equivalent in every respect to two single phase meters mounted on a common shaft. They either assist one another or the torque of one element opposes the torque of the other in proportion to phase displacement below 50 per cent power factor. To explain this condition further, we can refer to diagram, one which shows the typical connections of a polyphase meter. Note the potential connections 1-3 and assume the current coil connected in 1. This immediately gives a condition of the current 1-0 that meter element leading its potential by 30 deg.

Now note that the other potential is connected as 2-3 with its current coil in 2 and we have the reverse of the above in that the current 2-0 lags 30 deg. behind its potential.

This gives us a 30 deg. current lead in element No. 1 which is offset by the 30 deg. current lag in element No. 2 or a resultant of zero displacement, which is more commonly referred to as unity power factor, though the individual elements operate at the same speed with a displacement of 30 deg. or a power factor of 86 per cent each.

Inasmuch as current innately lags or leads its potential by 30 deg., in a simple diagram we will now consider a condition of an 86 per cent power factor, where the circuit current lags its potential by 30 deg.

In this consideration, we will refer to diagram Fig. 2 and while we note our physical connections remaining as in Fig. 1, we actually find the current lagging as represented in A for No. 1 and B for No. 2.

Now we find that current A-1 is in phase with potential 1-3 while current B-2 now lags 60 deg. behind its

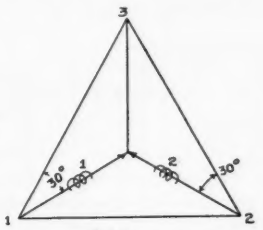


FIG. 1

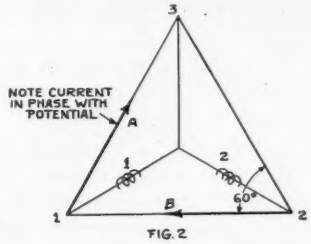


FIG. 2

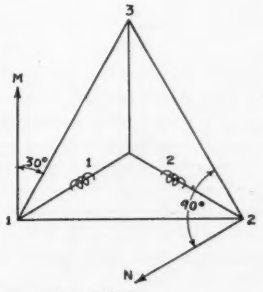


FIG. 3

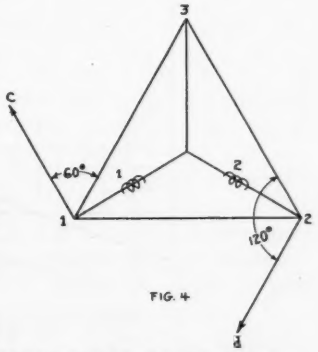


FIG. 4

FIG. 1. TYPICAL POLYPHASE METER DIAGRAM
FIG. 2. CONDITIONS FOR AN 86 PER CENT POWER FACTOR
FIG. 3. CONDITIONS FOR A 50 PER CENT POWER FACTOR
FIG. 4. IN THIS CASE, THE CIRCUIT CURRENT LAGS 90 DEG. AND THE POWER FACTOR IS ZERO

*Deceased. Formerly Assistant Chief Eng. Western United Gas & Electric Co.

potential 2-3. With this condition existing in element No. 1, the result is unity power factor in that element while element No. 2 with a displacement of 60 deg. operates at 50 per cent power factor and consequently runs with half the speed of element No. 1 but both elements operate in a forward direction.

To continue further, we can assume a 50 per cent power factor or a circuit current lag of 60 deg.

Now the current M-1 in element No. 1 will lag its potential 1-3 by 30 deg., while the current N-2 in element No. 2 will lag its potential 2-3 by 90 deg.

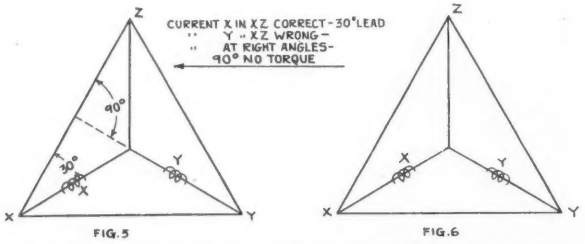


FIG. 5. DIAGRAM SHOWING ERROR INVOLVED IF A CURRENT AND POTENTIAL OF DIFFERENT PHASES ARE USED FOR EITHER ELEMENTS

FIG. 6. DIAGRAM FOR EXPLAINING FURTHER CONSIDERATIONS REGARDING POWER FACTOR AND METER CONNECTIONS

With a current lag of 30 deg. in element No. 1, the power factor of that element is 86 per cent but with a current lag of 90 deg. in element No. 2, the current is at right angles to its potential, therefore, it has no influence with a result that zero power factor exists in that particular element.

With zero power factor we have no torque, consequently it stands still and element No. 1 registers all of the power at an individual power factor of 86 per cent or a circuit power factor of 50 deg.

Now if we go still further and assume a circuit current lag of 90 deg., we shall have a power factor of zero; for the current C-1 in element No. 1 will now register 60 deg. lag with its potential 1-3 while the current d-2 in element No. 2 will lag 120 deg.

When a current lag exceeds 90 deg., the cosine of the angle becomes the same as the sine of the difference between the angle and 90 deg. In this case, 120 deg.—90 deg. is equal to 30 deg. which is the same as a (minus) power factor of 50 per cent and as a 60 deg. lag in element No. 1 is equal to a (positive) 50 per cent power factor due to cosine of a 60 per cent angle equaling 50 per cent power factor, the result is, both elements tending to rotate in opposite directions at half speed and as a consequence, neutralize each other's efforts.

It can readily be seen from these illustrations that the mere opening of an element connection to ascertain forward rotation of the remaining element is no check on the accuracy of the connection, unless the power factor is known, and in referring to Fig. 5, one can note the extreme error involved if a current and potential of different phases are used for either element.

For better illustration, let us assume that in a simple diagram, current Y was connected to potential XZ for element No. 1 we would at once have our current at 90 deg. variance with our potential whereas with correct connections, the current X would be connected to XZ at a lead of 30 deg. conforming to an individual element power factor of 86 per cent.

To check a polyphase instrument properly, we shall take our simple diagram again and change our potential connections from XZ to XY; with a unity power factor, the readings will be the same. If the power factor is under unity and over 50 per cent, the readings will differ and may be either positive or negative, but in the same direction.

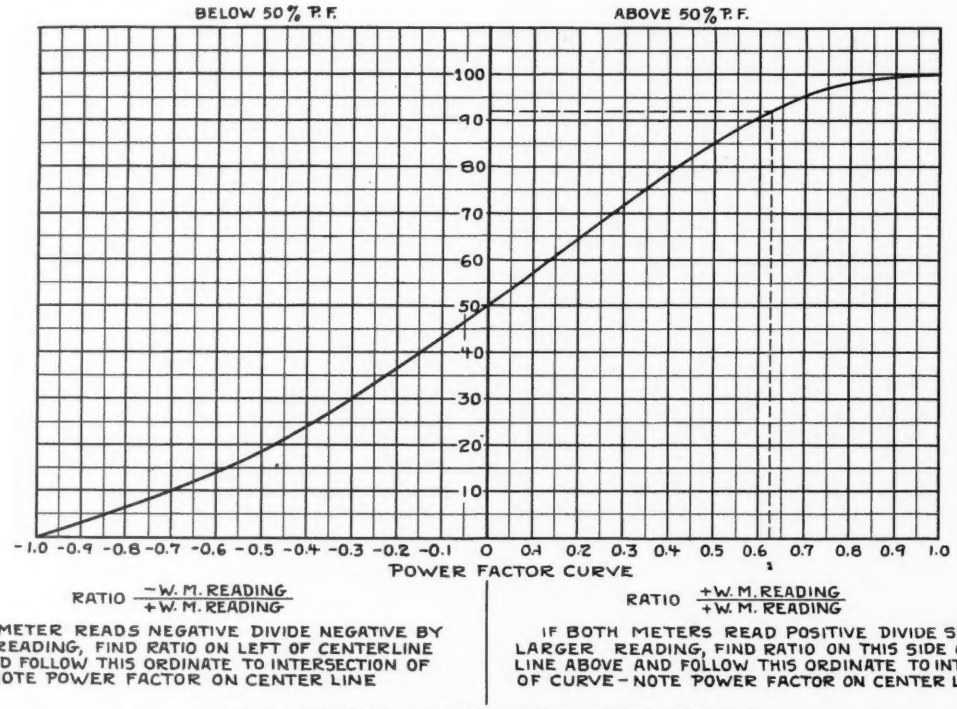

BELOW 50% P.F.
ABOVE 50% P.F.
100
90
80
70
60
50
40
30
20
10
-1.0 -0.9 -0.8 -0.7 -0.6 -0.5 -0.4 -0.3 -0.2 -0.1 0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0
POWER FACTOR CURVE
RATIO −W. M. READING / +W. M. READING
IF ONE METER READS NEGATIVE DIVIDE NEGATIVE BY POSITIVE READING, FIND RATIO ON LEFT OF CENTERLINE ABOVE AND FOLLOW THIS ORDINATE TO INTERSECTION OF CURVE - NOTE POWER FACTOR ON CENTER LINE
RATIO +W. M. READING / +W. M. READING
IF BOTH METERS READ POSITIVE DIVIDE SMALLER BY LARGER READING, FIND RATIO ON THIS SIDE OF CENTER-LINE ABOVE AND FOLLOW THIS ORDINATE TO INTERSECTION OF CURVE - NOTE POWER FACTOR ON CENTER LINE

FIG. 7. CURVE FOR DETERMINING POWER FACTOR

In this test, a 50 per cent power factor will cause one of the readings to be zero and if less than 50 per cent power factor, the individual readings will be reversed with respect to each other. This same test may be conducted on the other element with same procedure and results.

On the conclusion of this test, the current coils of both elements will be properly connected if they each give a forward reading on power factors over 50 per cent; on power factors of less than 50 per cent, the current coil of the faster meter should be connected to give forward rotation with the slower element connected to read in a reverse connection.

Power factor can be determined by referring to the accompanying diagram, or figured directly if kv-a. and kw. readings are either available or can be ascertained. For example, kw. readings on a 15-hp. motor at 35 lb. water pressure on a pump were found to be 12.48; amp., 35.6; voltage, 220; 3 phase circuit.

The ratio of wattmeter elements was found to be 129/186.

This ratio gives us 129 ÷ 186 or 64 and by following 64 to intersection of curve, our power factor is found to be approximately 92-93.

The kv.a. from readings are $220 \times 35.6 \times 1.73 = 13.56$ or a power factor of 92.

Stop Losses in Services Rendered to the Plant

PART II.* SOME OF THE LOSSES THAT OCCUR IN SUPPLYING ELECTRICITY, COMPRESSED AIR AND REFRIGERATION TO INDUSTRIAL PLANTS AND HOW TO CORRECT THEM

DUE TO THE FACT that except in the most apparent cases, loss of electric energy can take place without the knowledge of even the most observant workman, frequently a large percentage of the electric power generated in the engine room never gets to the motors or lights for use. Unlike water or steam, electricity cannot be seen to escape from conductors except in the most flagrant cases of grounds or short circuits. In hunting losses, therefore, the engineer must be provided with instruments for the purpose, those found most necessary being voltmeters, ammeters, wattmeters and thermometers.

Electric energy that is lost by the consumer is usually converted into heat which is dissipated to the surrounding atmosphere or objects. Ordinarily the temperature rise around an electrical conductor or device is not sufficient to cause alarm and until it reaches a point where it is perceptibly hot, little thought is ordinarily given the device as long as it will operate. Any rise in temperature, however, above the surrounding atmosphere is caused by the losses in the operation of the equipment. Some of those losses are inherent and cannot be avoided; others are due to working conditions or defects that can be corrected. It is the latter type of losses with which the plant engineer is particularly concerned.

Considering first the losses due to transmission, it must be recognized that, measured in kilowatts, these losses are equal to the square of the current in amperes times the resistance in ohms of the conductor. The resistance increases in direct proportion to the distance the current is carried and decreases in direct proportion to the cross-sectional area of the conductor.

To reduce the energy loss due to transmission, three ways may be open—by reducing the length of the transmission line, increasing the size of the conductor and reducing the current carried without reducing the power transmitted.

SIGHT-SEEING TRIPS ARE EXPENSIVE

Nearly all of the older industrial plants have grown from small beginnings and few of them have found it advisable to follow the original plans for expansion. As a result, the electric circuit, being extremely flexible in arrangement, is extended here and there throughout the entire plant without much thought as to the total power losses due to the additional loads and their relation to the power house location.

In many plants, the transmission lines have a way of taking the plant kilowatts on an aerial sight-seeing tour about the buildings of the plant. With the generating equipment on the ground floor or below in one building and the heavy power using equipment on the lower floors of other buildings, it is quite common to see the transmission cables carried to the top of the power house building, then to the top of the other buildings which it serves, there to be carried down two, four or six floors to the principal equipment in the building, whereas an underground cable might cut the circuit in half and the transmission loss proportionately.

Where large amounts of power are to be transmitted, the line should go as directly as possible. The feeder following parallel with the walls of a building may be a necessary and convenient arrangement in some instances but the hypotenuse of a right triangle is shorter than the sum of the other two sides and the saving in power by the latter course will often pay many times over for the inconvenience it causes in building arrangement.

Increasing the area of a conductor may be done in two ways—by replacing the old with a new larger cable or by running an additional cable to help carry the load. In most cases, the latter is the more desirable arrangement. Frequently the new cable can be run directly to another load center, thus not only increasing the area of the conductors but shortening the transmission distance of part of the load.

To determine what might be done with the transmission circuit of an existing plant, the engineer must follow out the course of all the principal feeders and draw a plan and elevation, or better still, an isometric drawing, of each circuit by means of which he can study the possibilities of shortening the circuits.

While making an inspection of the circuits, it is a good time to observe the temperature conditions surrounding the line. To run electric lines in tunnels or building shafts that also accommodate the hot water or steam lines is a serious error for, with each 6 deg. F.

*The first installment of this series, of which this is the last, was published in the April 15 issue.

rise in temperature, the resistance of that portion of the line so affected is increased 1 per cent, which means a corresponding increase in power loss. If the voltage drop to a certain load is greater in winter than in summer, there can be little doubt that the heating piping is the cause.

Transmission lines should be kept as cool as possible. It is a mistake to put them in conduits that will not radiate heat readily. The heat radiated will equal the power lost, that is, the current squared times the resistance (I^2R). If the temperature difference between the cable and the surrounding mediums is not sufficient to radiate the heat generated, the temperature of the cable will continue to rise until a balance is secured and each degree rise increases the resistance and likewise the loss. Electric lines should be in the coolest parts of the buildings and in well ventilated locations.

Reducing Current Without Diminishing Power

To keep the current in a circuit down to a minimum is more important than reducing the resistance, for the power loss increases as the square of the current; if the current is doubled, the transmission loss is quadrupled. Other conditions being equal, the power loss on a 110-v. transmission line is four times as great as on a 220-v. line.

In a survey of the electric circuits, careful note should be made of the points where the three-wire 110-v. lighting and motor circuits take off from the 220-v. circuits as considerable power can frequently be saved by lengthening the 220-v. feeders and shortening the 110-v. lines.

Correcting motor operating conditions, however, is likely to give greater reductions in power loss than rearrangement of the circuits. Motors should be the proper size for the load they are to carry. Either an over or under loaded motor draws more current than should be necessary and it should always be remembered that every additional ampere drawn by the motor pyramids the losses all along the line.

In alternating current circuits marked savings have been effected by improving the power factor of the system. In such cases, not only are the line losses reduced but the reduction of current improves greatly the operating efficiency of the generator and motors. Every condition which reduces the efficiency of the motors will call for more current from the system with the losses mounting more rapidly; so it behooves the engineer to keep the motors in the pink of condition.

Transformers and motor starters, too, have characteristics that call for more current than is warranted when they are not working under conditions for which they are designed. With a growing load in a factory that is expanding, the electrical conditions are almost sure to change, consequently placing on the equipment condition for which it was not designed. These conditions, the engineer must seek out and correct wherever possible.

What Voltage Indications Will Show

Hunting for preventable losses may not be an exciting experience but in most industrial plants it is a profitable occupation. Probably the best indication of the electrical condition of a system is a voltage survey under varying conditions of load as they exist in the plant throughout the day or week. For this work, a portable voltmeter is necessary. The voltage drop between the generator switchboard and the ends of the various feeders and farther out to the load centers and large motors will indicate what lines are too small for this service. Ammeters are essential in checking up the load on motors to see that design conditions prevail and with alternating current systems, the wattmeter is also essential for determining power factor.

Many engineers have assumed that if the power factor in one part of the system is high, that condition exists throughout the entire system. This is not necessarily true and a survey of the system should include the determination of the power factor at various points under the varying conditions that take place in the plant. Sometimes merely shifting different types of motors will relieve a troublesome condition.

Compressed Air Is Easily Lost

One of the services which a power plant usually renders a factory is that of supplying compressed air. The losses encountered here are usually due to leaks which allow the air to escape without performing the service for which it was pressed. Escaping air is invisible and leaks of considerable size may exist, under some conditions, without making the characteristic hissing noise. Many heating radiators make the same sort of noise when operating properly and thus confuse workmen. Noisy machine shops may drown out the hiss of escaping air and air pipes run in shafts or tunnels may leak unnoticed for an indefinite period if not inspected frequently.

Not only pipe leaks but hose connections, air valves in blowing nozzles, worn-out hose and carelessly closed and worn-out valves are the causes of considerable compressed air escaping with a loss of power proportional to the amount of air that gets away.

In many plants, compressed air is used as power to drive small tools, pump liquid by means of ejectors or mix chemicals. In any of this service the pressure must be maintained and the same condition of reduced pressure due to pipe friction is encountered here as with steam.

To determine that losses do or do not exist is the first step and no instrument is more convenient than a portable pressure gage that can be connected at various points in the piping system. A 10 to 15 per cent drop in pressure between the receiver and the device operated by compressed air while the system is in normal operation is about what should be expected. When the drop gets as high as 25 to 40 per cent, the condition represents an exorbitant loss of power that should be corrected.

Such drop in pressure is due to pipe and valve friction or leaks. Like electric circuits, compressed air piping is conveniently extended and branches are added as the factory workmen find need for them without much thought as to the design of the whole system. As a result, a survey of the system that is giving trouble from low pressure will usually disclose sections of piping that are too small for the service or so full of right angle bends as to use up an unwarranted amount of power in friction. The remedy, of course, is larger pipe, more direct piping to centers of load or shorter runs of piping from the compressor. Sometimes it is

advisable to locate the motor driven compressor out in the factory close to the point where it is used.

In redesigning the piping system, an isometric drawing of the piping as its exists is most helpful in determining where bends can be eliminated and how the center of distribution can be reached most directly.

To ascertain whether or not leaks in the system are excessive, make note of the rate at which the receiver pressure drops when none of the machinery is in operation, i. e., the compressor stopped and valves to the various devices closed. If the piping system is perfectly tight, the pressure will hold up indefinitely. This condition is seldom expected and even a 25 per cent drop over a period of 12 hr. would not be considered exorbitant in the average plant. This test in many plants will reveal that the pressure will drop almost to that of the atmosphere in 2 or 3 hr. When this occurs, a diligent search is essential to determine where the air is getting away. In some systems, it is possible to test isolated sections of the piping in the manner described but without a received in the section tested the pressure drop will be more rapid and this must be taken into account when judging the seriousness of the leaks.

Where leaks exist, each pipe line should be inspected from one end to the other. Large leaks will be evident and one of the best ways to detect the smaller leaks is to paint the joints with soapy water.

Wherever refrigeration is used in industry, its purpose is to lower the temperature of the surrounding atmosphere or objects, so when conditions exist that cause this lowering of temperature to extend to air or objects that are not required to be at a lower temperature, a loss in refrigeration is taking place. This is the principle which should govern the search for losses in refrigeration systems.

In nearly all cases, insulation is the answer to the problem of refrigeration losses. Ice water and cold brine piping should be as short as possible and well insulated. All containers of chilled liquids need protection against the heat of the surrounding atmosphere. Cold piping should be kept as far as convenient from steam and hot water piping; if possible, it should not be run through engine rooms or other rooms where excessive heat exists. Considerable heat gets into refrigerating rooms through the doors, so it is important that these be kept closed except during actual use, the self-closing type being preferred in most cases. Double doors with a short space between them which will allow only one door to be open at one time will prevent considerable loss, particularly from rooms held at temperatures below zero.

With products going continuously in and out of refrigerating room, it is difficult to determine the actual refrigerating losses but at various times, such as holidays or when products are not being moved, the engineer should check up on the power used in refrigerating. Once the temperature in a refrigerating room has reached a low constant, the refrigeration required to keep it there is all loss due to heat absorption from the surroundings. Comparisons of power used over similar like periods will indicate whether or not insulation is deteriorating.

To find insulation leaks, nothing compares with thermometers used periodically around refrigerating piping and cold storage rooms and containers. Wherever the temperature close by such equipment feels perceptibly cooler than the atmosphere a foot or two away, the loss is excessive as with economical insulation the sense of touch cannot reveal the loss. The place where the temperature difference between the surface of the insulation and the general atmosphere is more than 2 or 3 deg. should be investigated for defective or insufficient insulation.

To stop the losses in the services rendered by the power plant requires a detailed study of conditions surrounding that individual plant and no amount of generalization can do more than indicate some of the conditions that have been corrected in some plants. Surveys, for the purpose of indicating loss, must be sufficiently detailed as to point to exact places where losses occur or they cannot be corrected.

Coal Mining Methods

COAL MINING in the midwestern fields is carried on by three or four different methods: the room and pillar, the panel, the longwall and stripping methods.

In the first, pillars of coal are left to support the roof and prevent settling of the ground above. By this method, an average of about 50 per cent of the coal is removed, the remaining half being left as pillars.

The panel system is somewhat similar except that the mine is blocked off in large plots or panels with extra wide pillars. In each panel, mining is carried on as before and after the panel is worked out, it is cut off by brick walls to save the cost of ventilation and airway maintenance.

For the thinner seams, the longwall method is used. A sufficient block of coal is left in the center to support the shaft and plant. Around this core, coal is mined out in an ever-increasing circle, leaving the entire circumference of the circle as an open face or long wall. Shale from entries and undercutting is used to fill in behind the coal face and to prevent undue settlement of the overburden. A large percentage of coal is received by this method but much waste material must be handled and the production cost is high.

When the overburden is not heavy, stripping is practiced with the coal mined by steam shovels in an open pit. These mines are developed at lower first cost than are shaft mines but the life is shorter and as the land is rendered worthless, the expense of developing these mines where land is of value for agriculture is considerable.

CRISP COUNTY POWER COMMISSION, Cordele, Ga., has active construction in process on its new hydroelectric plant on the Flint River, near Cordele, for which an appropriation of $1,250,000 was voted recently. The station will have an initial rating of 18,000 hp., to be available for industrial power service, as well as residential lighting throughout this section. Excavation for the power house has been completed and superstructure will be placed under way at once; work is close to 50 per cent complete on the main power dam. In connection with contracts, an award has been made to the Newport News Shipbuilding & Dry Dock Co., Newport News, Va., for hydraulic machinery and to the General Electric Co., Schenectady, N. Y., for generating and auxiliary electrical equipment.

Aurora Plant Fires Coal 93 per cent Through 200 Mesh

Western United Gas & Electric Co. operate three of six 1000 hp. boilers with pulverized coal. Each boiler has two ball mills pulverizing coal with a power consumption of 14.1 kw. per T. and a maintenance charge of $0.016 per ton of coal fired.

AT THIS TIME when the controversy regarding the necessary fineness of pulverized coal is at its height, operating results of the ball mill installation of the Western United Gas & Electric Co. at Aurora, Ill., are of particular interest.

Due to the fine grinding characteristics of ball mills, the fuel burned under these three 1000-hp. boilers averages about 93 per cent through 200 mesh and 100 per cent through 50 mesh. In Table I are given the best and poorest results of a great many screen tests. Both samples were taken with the boiler operating 275 to 300 per cent of rating, that is, about 90,000 lb. of steam per hour, which corresponds to a total coal feed of 10,000 lb. per hr. or 5000 lb. per hr. per mill.

TABLE I. SCREEN TESTS OF PULVERIZED COAL SHOWING THE BEST AND POOREST OF A GREAT MANY TESTS. ALL TESTS WERE TAKEN AT A STEAM FLOW OF 90,000 LB. PER HR. CORRESPONDING TO ABOUT 5000 LB. OF COAL PER HR. THROUGH EACH OF TWO MILLS

	1st Sample		2nd Sample		3rd Sample	
	So.Mill	No.Mill	So.Mill	No.Mill	So.Mill	No.Mill
200	93.70%	96.34%	95.14%	96.36%	85.40%	82.00%
100	99.44%	99.78%	99.76%	99.76%	97.50%	97.06%
80	99.80%	99.94%	99.92%	99.94%	98.86%	98.76%
50	99.98%	100.00%	100.00%	100.00%	99.84%	99.82%

When the fineness drops to about 78 per cent through 200 mesh, slagging troubles are encountered. This condition which experienced operators can detect without screen tests by the sound of the larger coal particles on the feed pipe to the burners, is immediately remedied by charging the mill, while operating, with the proper amount of balls.

From many months operating experience, it has been determined that the mills use 0.33 lb. of balls per ton of coal and 333 lb. of balls are fed in for each 1000 t. as determined from the weigh meter readings. The initial charge to each mill is 14,700 lb. of Herculite steel made up of 3, 2, 1½ and 1-in. balls. After the initial charge, only 3 and 2-in. balls are used, the proportion of smaller balls being maintained automatically by wear.

Power consumption of the mills alone averages about 14.1 kw-hr. per ton of coal pulverized. Due to the characteristics of the mills operating at all times with a constant charge of balls, the power consumption over the entire load range is almost constant and the partial load at which the mills are operated some of the time increases the power consumption per ton considerably above what it would be if the mills were operated at full capacity continuously. At 5000 lb. per hr., the exhauster fans driven by 20 hp. motors require about 9 kw. each. Total power consumption of the entire boiler unit including mills, fans, regulators, feeders and induced draft fans average about 53 kw-hr. per t. of coal.

Total maintenance of mills, exhausters and feeders amounts to about 1.6 cents per t. This includes the replacement of some liners, at the feed ends of the mills which is the only section showing appreciable wear. Liners are of the same material as the balls, that is Herculite steel.

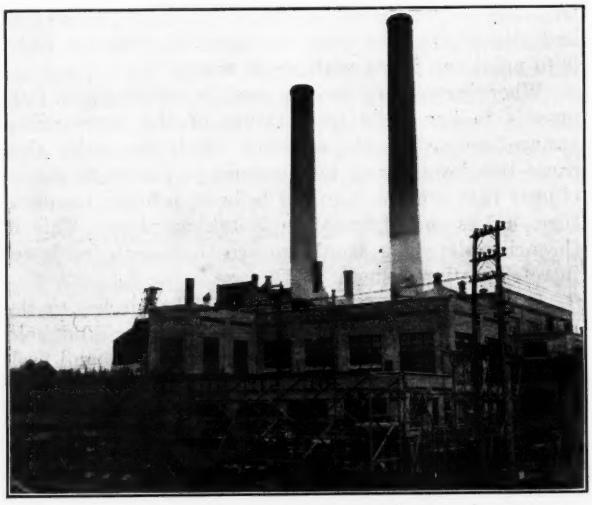


FIG. 1. EXTERIOR OF THE AURORA STATION. THE TOTAL GENERATING CAPACITY IS 48,375 KV-A.

Mills Maintain Fineness with 12 Per Cent Moisture

A typical analysis of the coal used, both ultimate and proximate, is given in the tabulated results of the test of No. 1 boiler, Table II. This fuel, with about 10 per cent ash, is Old Ben Coal Co. screenings running around 11,600 B.t.u. per lb. as fired. The mills have maintained 85 per cent through 200 mesh with 12 per cent moisture in the coal.

Because of the arrangement and design of the plant and the various boiler units installed, engineers are in an exceptionally good position to judge the relative efficiencies of various boiler constructions and methods of firing under similar conditions of operation and fuel.

Originally, the boiler plant was laid out with six boiler units as shown in the plan, Fig. 2. With the exception of Units No. 2A and 2B, low-pressure 500-hp. heating boilers set in a battery, they were 1000-hp., 325-lb. gage, 200-deg. F. superheater units fired by chain

TABLE II. RESULTS OF A 52-HR. BOILER TEST ON UNIT NO. 1

	Duration: 52 Hr. Observers: R.F.Larson, E.W.Pride, L.Cook		
1.	NAME OF FUEL: Old Ben Screenings		
	FUEL ANALYSIS - PROXIMATE (As Fired)		
2.	Volatile Matter per cent		31.28
3.	Fixed Carbon per cent		48.99
4.	Ash per cent		10.08
5.	Moisture per cent		9.65
	ULTIMATE ANALYSIS (As Fired)		
6.	Carbon per cent		64.90
7.	Hydrogen per cent		4.48
8.	Oxygen per cent		9.01
9.	Nitrogen per cent		1.29
10.	Sulphur per cent		.99
11.	Ash per cent		9.68
12.	Combustible in Ash and Refuse, per cent		9.5
13.	B.t.u. by calorimeter per lb., dry		12,886
14.	B.t.u. by calorimeter per lb., as Fired		11,610
	FLUE GAS ANALYSIS		
15.	Boiler Outlet - CO_2-14.7 O_2-4.6 N_2-80.3		
16.	Econ. Outlet - CO_2-14.7 O_2-4.5 N_2-80.4		
	PRESSURES and DRAFTS		
17.	Steam Press., Boiler Gage, lbs/sq.in.		332
18.	Steam Press., Superheat Outlet		322
19.	Barometer In. Hg.		29.5
20.	Barometer lbs/sq.in.		14.5
21.	Draft in Furnace in H_2O		0.05
22.	Draft in Uptake in. H_2O		1.12
23.	Draft loss through Econ. in H_2O		2.1
24.	Draft loss through Air Preheater in H_2O (Air)		0.5
25.	Draft loss through Air Preheater in H_2O (Gas)		1.7
	TEMPERATURES		
26.	Steam Temp. at Boiler, deg. F.		428
27.	Steam Temp. Total " "		617
28.	Superheat " "		189
29.	Feedwater entering Economizer, deg.F.		210
30.	Feedwater leaving Economizer " "		293.5
31.	Flue Gas, Boiler Outlet " "		632
32.	Flue Gas, entering Economizer " "		632
33.	Flue Gas, leaving Economizer " "		353
34.	Flue Gas, entering Air Preheater" "		353
35.	Flue Gas, leaving Air Preheater " "		314
36.	Boiler Room Temperature " "		82.7
37.	Air leaving Detrick Wall " "		146.5
38.	Air leaving Air Preheater " "		270.0
39.	Air entering Air Preheater " "		146.5
40.	Air and Fuel entering Burner " "		147.0
41.	Secondary Air around Burner " "		270.0
	HOURLY QUANTITIES		
42.	Fuel as Fired per hour, lb.		10,100
43.	Steam Evaporated per hr., lb.		88,600
44.	B.t.u. liberated per cu.ft. comb. space		19,570
45.	Coal pulverized per mill		5,500
46.	Rated capacity of mill		6,000
	ECONOMIES and RESULTS		
47.	Factor of Evaporation		1.17
48.	Per cent of Rating		292
49.	Actual Evap. per lb. coal as Fired		8.77
50.	Equiv.Evap. per lb. coal as Fired		10.27
51.	Eff. of boiler, superheater, Econ. and Air Preheater (Overall)	(BTU) 9,970	(%) 85.8
52.	Eff. of boiler, superheater and Econ.	" 9,878	" 85.0
53.	Eff. of boiler and superheater	" 9,138	" 78.64
	HEAT BALANCE (Based on Fuel as Fired)	(BTU)11,610	
54.	Heat absorbed by boiler and superheater	9,138	78.64
55.	Heat absorbed by Economizer	740	6.36
56.	Heat absorbed by Air Preheater	92.3	.80
57.	Heat loss in dry chimney gases	611	5.25
58.	Heat loss due to moisture in fuel	111.4	.96
59.	Heat loss due to burning H_2 in fuel	348	2.99
60.	Heat loss due to moisture in Air (not figured)		
61.	Heat loss due to CO	0	.00
62.	Heat loss due to combustible in Ash and Refuse	100	.86
63.	Heat loss due to Radiation and Unaccounted for Losses		4.14
	POWER CONSUMPTION--KW per ton (Coal as Fired)		
64.	Total Power Consumed	47	

grate stokers set as shown for Boiler No. 5 at the left of the section Fig. 3. One of these original units, No. 4, was later rebuilt with Bailey water-cooled side walls, rear and front arch, as shown at the right-hand side of the same section.

Following this, the remaining three power units, that is, Nos. 1, 3 and 6 were later rebuilt for pulverized coal as shown in the cross section Fig. 5. These units

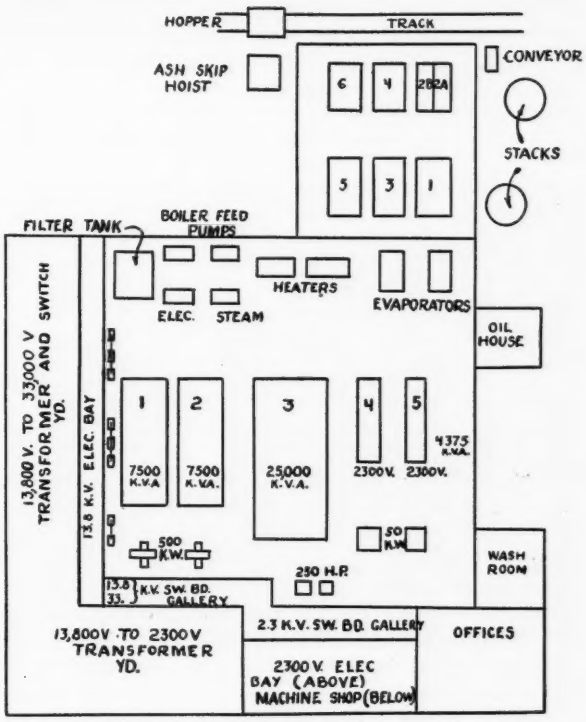


FIG. 2. PLAN OF THE AURORA STATION OF THE WESTERN UNITED GAS & ELEC. CO.

have superheaters, 3744-sq. ft. economizers, 6380-sq. ft. plate air heaters, 764-sq. ft. of water-cooled furnace walls, air-cooled front wall and a 6000 cu. ft. furnace. Each boiler is equipped with two Kennedy-Van Saun 5 ft. dia. by 9 ft. long, air swept ball mills. More complete data are given in Table III.

These mills, on the basement floor just in front of the ash hopper, are set with the discharge ends together and their longitudinal axes parallel with the boiler drums. Each mill supplies two horizontal burners. Air for combustion is taken from the air-cooled front wall up through the air heater and delivered as secondary

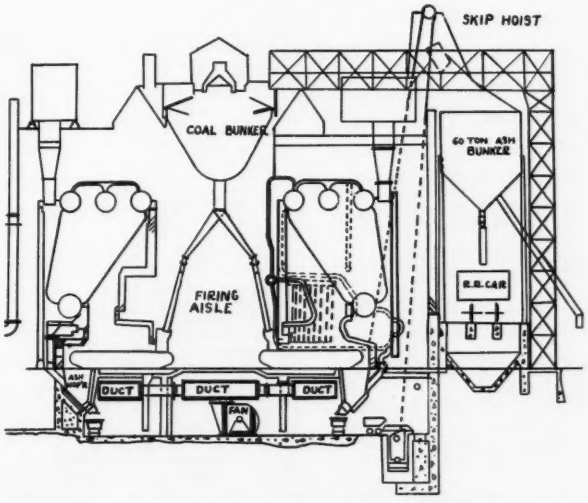


FIG. 3. UNIT NO. 5 (LEFT) WITH REFRACTORY LINED FURNACE AND NO. 4 (RIGHT) WHICH WAS REBUILT WITH WATER WALLS AND ARCHES

TABLE III. GENERAL DATA ON THE THREE PULVERIZED FUEL FIRED UNITS

MAKE:	Babcock & Wilcox, Stirling Type, Class 13 - No.36 3 drums - 42" Dia. by 21' 10⅝" long, press. 325 lb.	
HEATING SURFACE:	(Sq. Ft. effective)	
	Boiler Proper	10,012
	Side Walls	400
	Rear Wall and Hopper	364
	Total	10,776
	Detrick air-cooled front wall	
SUPERHEATERS:	Boilers No.1 and No.3, B & W	
	Heating Surface, sq.ft.	2,430
	Boiler No.6, Foster	
	Heating Surface, sq.ft.	1,746
ECONOMIZERS:	Foster Counter Current	
	Heating Surface, sq.ft.	3,744
AIR PREHEATER:	Combustion Engr. Steel Plate	
	Heating Surface, sq.ft.	6,380
PULVERIZED COAL BURNERS & MILLS		
	Kennedy Van-Saun Fish Tail Modified	
	Burners and 5 by 9 ft. air swept Ball Mills	

air to the burners at a temperature of from 250 to 300 deg. F. at normal rating.

About 30 per cent of the total air for combustion is taken through the mill. This is preheated air from the forced draft ducts, the entering temperature of 250 to 300 deg. F. being reduced to about 150 deg. for the mixture of coal and air at the discharge end of the mill. By means of an ingenious arrangement of dampers, the air through the mill is maintained nearly constant, by a Carrick electric type regulator, at all loads so as to give uniform pulverization at all ratings.

Draft in the mill is maintained slightly below atmosphere, the pulverized coal being carried from the mill with the air handled by the primary air or exhauster fan located directly above the feed ends of the mills. This fan feeds the pulverized coal to the burners. After passing the Richardson automatic scale raw coal is fed to the mills by a rotary table feeder on the operating floor.

Comparative efficiencies of the five power units are given in Table IV. For convenience a summary of No. 1 test given in detail in Table II is included. It should be kept in mind that Boilers Nos. 1, 3 and 6 are pulverized coal fired while 4 and 5 are stoker fired, No. 4 with water walls and No. 5 with refractory walls. The

TABLE IV. TESTS ON THE PULVERIZED COAL UNITS SHOW CONSIDERABLY HIGHER EFFICIENCY THAN DO THE STOKER FIRED UNITS

		Pulv.Coal	Pulv.Coal	Stoker Water Walls	Stoker	Stoker	Pulv.Coal
	TEST NO.	1	2	3	4	5	6
1.	Boilers Number	1	3	6	4	5	6
2.	Hours on Line	52	24	23½	24	18 1/3	17½
3.	Avg. Press. gage	332	319.2	317	307.7	300.6	302.5
4.	Avg. F.W. Temp.deg.F.	210	211	252	252	252	211
5.	Avg. Steam Temp.deg.F.	617	623	623	600	595	592
6.	Superheat deg.F.	199	206	211	180	167	174
7.	Total Steam		2,058,000	2,132,000	1,821,000	1,019,000	919,000
8.	Total Coal, lb. (Banking Excl.)	513,000	232,800	234,800	211,400	129,100	112,800
9.	Banking Coal					1,500	1,000
10.	Actual Evap.	8.77	8.82	9.07	8.62	7.88	8.15
11.	Factor of Evap.	1.17	1.179	1.15	1.126	1.119	1.129
12.	Equivalent Evap.	10.27	10.39	10.44	9.70	8.82	9.19
13.	Overall Eff.	85.8	84.90	85.40	82.8	75.80	78.60

		202,800
		1,000
		9.62
		1.087
		10.42
		85.30

four pulverized coal tests show an average overall efficiency of well above 85 per cent at 300 per cent rating, the water-cooled stoker fired boiler about 83 per cent at 250 per cent rating while the remaining stoker fired unit with plain walls averages about 77 per cent at a rating of approximately 200 per cent rating. Tests Nos. 3, 4 and 5 were made the same day, Nos. 2, 6 and 7 were made about a week later and No. 1 was made the next month.

FIG. 4. FRONT VIEW OF NO. 6 PULVERIZED FUEL-FIRED FURNACE

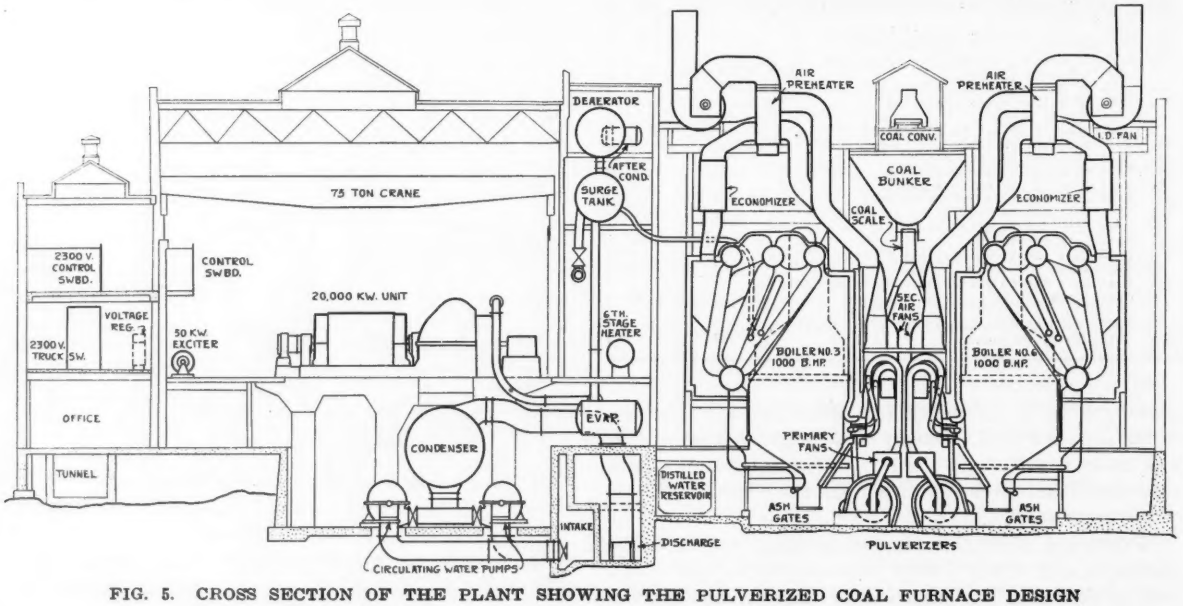


FIG. 5. CROSS SECTION OF THE PLANT SHOWING THE PULVERIZED COAL FURNACE DESIGN

They were all made by R. F. Larson of the Department of Mechanical Engineering at the University of Illinois. Coal analyses were made by the Pittsburgh Testing Laboratory of Chicago, Ill., and all tests were conducted according to the A. S. M. E. Test Code with carefully checked and calibrated instruments. Each test was preceded by at least 4 hr. of constant steam delivery. Pulverized coal samples from complete traverses across two diameters of the pipe were taken by means of a sampling tube and vacuum cleaner from a duct leading to the burner.

Steam generated was measured by a 3-in. Simplex Venturi feedwater meter that had previously been checked against a Bailey steam flow meter and was found to differ less than 2 per cent on repeated tests. It was necessary to bypass the third stage heater during the tests so that feedwater entered the boiler at about 50 deg. F. lower than normal. Goodenough's steam tables were used in the calculations.

Boiler No. 1 was put in service but a few days before the 52-hr. test, reported in Table II with an overall efficiency of 85.8 per cent. Inherent losses in this test total about 8.18 per cent giving a theoretical available efficiency of 91.82 per cent. Overall efficiency calculated on the basis of that theoretically available is 93.5 per cent indicating 6.5 per cent preventable losses. Fuel distribution to the modified burners was not good at the time of the test although the results reported are unusually good.

TABLE V. FROM THE STATION RECORDS THE HEAT CONSUMPTION IS ABOUT 16,700 B.T.U. PER KW. SENDOUT

Average Back Pressure	.87
Maximum Peak Load, kw.	20,000
Minimum Load, kw.	8,000
Total kw.hr. Gen.	351,000
Station Consumption	19,300
B.t.u. supplied per kw.hr.gross	15,510
B.t.u. supplied per kw.hr.net	16,700
Water Rate on Turbine, gross	10.39
Water Rate on Turbine, net	10.98

Boiler No. 3 had burners with flared tips. With these burners, it was impossible to get above 14 per cent CO_2 without smoke. Gas analysis indicated 21.4 per cent excess air for best efficiency.

Boiler No. 6 is equipped with Foster superheaters which were coated with flyash and soot so that instead of 200 deg. F superheat normally expected, only 96 deg. F. was obtained. This loss in superheat resulted in higher gas temperatures, consequently higher air temperatures from the heater. With the higher furnace temperature, combustion was completed with only about 10 per cent excess air. Gas samples were taken showing 17 per cent and CO_2 with no CO. This, however, caused excessively high furnace temperatures which melted the Detrick walls. CO_2 in excess of 16 per cent is not used for actual operation. Ash collected from the flue gases showed only 6 per cent combustible as compared to about 20 per cent for boiler No. 3.

The new 20,000-kw. General Electric generating unit shown in Fig. 6 with Chief Engineer H. J. Olson standing beside it, is the latest addition to the generating equipment of the station and brings the total capacity of the station up to 48,375 kv-a. (38,700 kw. at 80 per cent power factor). Arrangement of the five generating units with the exciters, rotary converters, boiler feed pumps and evaporators is indicated in Fig. 1.

As shown in Fig. 7, the 20,000-kw. turbine, a nine-stage machine is bled at the third and sixth stage for the evaporators and stage heaters. Makeup supplied by the evaporators from river water averages about 4.2 per cent as determined from meter readings over a period of several weeks. This loss, due to steam used for cracking scale from evaporators, soot blowing, blowdown, auxiliaries exhausting to atmosphere, etc.

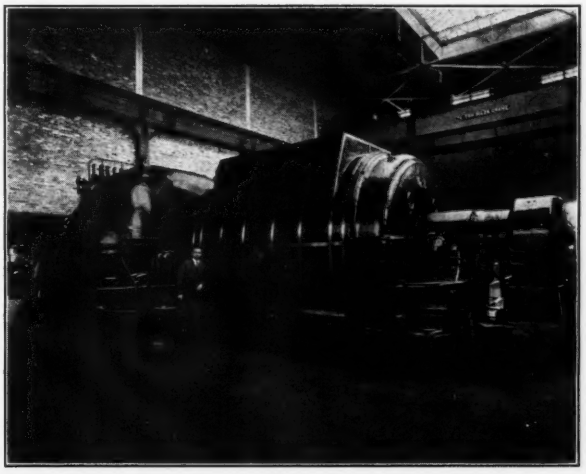


FIG. 6. CHIEF ENGINEER H. J. OLSON WITH THE NEW 20,000-KW. UNIT

From the continued operating efficiency of this plant over a period of several months, the complete absence of slagging troubles, excellent combustion conditions in the furnace with an almost transparent flame similar to a gas fire; continuous high ratings of 250 to 350 per cent which are carried and, above all, the low maintenance costs combine to make this plant one of the most interesting pulverized coal installations in the country and one which cannot be neglected when the necessary fineness of pulverization is discussed.

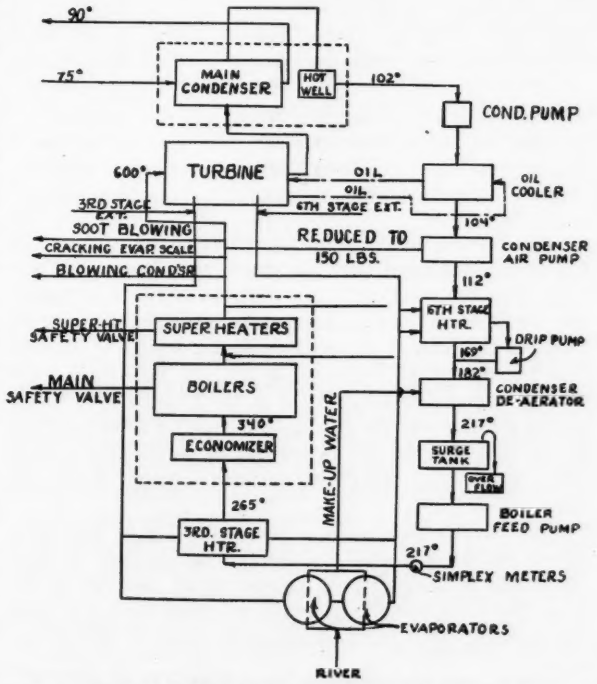


FIG. 7. FLOW DIAGRAM OF THE STATION. TWO-STAGE EXTRACTION IS USED

Air Compressors Should Be Properly Installed

CAREFUL ATTENTION TO RECEIVERS, AFTERCOOLERS, PIPING AND TRAPS RESULTS IN ELIMINATION OF PULSATION, MOISTURE IN AIR AND OTHER TROUBLES. BY FRANK A. HALLECK*

IT IS BAD practice to install an air-compressor plant without a receiver or aftercooler. If these are omitted, oil moisture, etc., are carried direct to the pipe line and from there to wherever the air is used.

It is worse if the air discharge line is buried underground, as the whole pipe line then remains hot; it also forms a pocket to accumulate all the oil and moisture discharged from the compressor. These impurities remain indefinitely in the buried pipe, as there is no convenient means of cleaning it.

Despite all the propaganda against installing valves in the discharge line between compressor and air receiver, there have been several disastrous explosions due to compressors being started with such a valve closed. If it is necessary to place a valve between the compressor and the receiver, a safety valve must be placed in the line between the air cylinder and the stop valve. The object of the safety valve is to act as a warning signal for starting the compressor. If the safety valve blows, it shows that the stop valve has been left closed; the machine should be shut down and the valve opened before it is again started.

SIZE OF DISCHARGE LINE SAFETY VALVE

Since the safety valve, as here used, acts as a signal, its size is not so important but the following table, which is recommended by the Compressed Air Society, shows approximate sizes to use. This table also shows sizes of discharge pipe recommended.

Safety Valve Size in inches	Displacement of Compressor Cu. ft. per min.	Size of Discharge Pipe Inches
¾	10 to 200	2
1	200 to 400	2½
1½	400 to 650	3
2	650 to 1000	4 to 6
2½	1000 to 1500	6 to 8
3	1500 to 2500	8 to 10
4	2500 to 4000	12 to 14

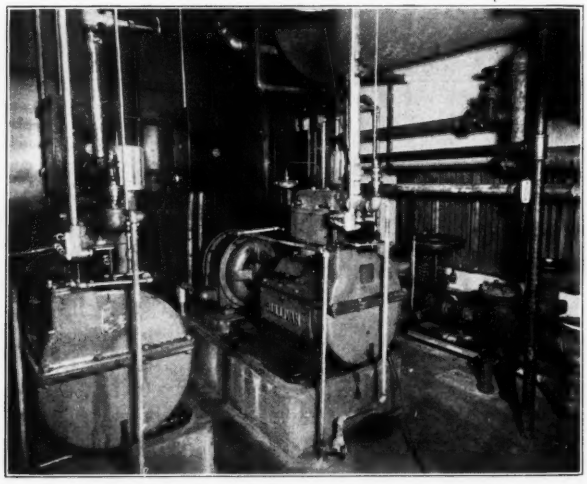
Air receivers should be set outdoors. After the air has been discharged into the receiver, it is usually carried from the receiver to the distributing line to where the air is to be used. As the air cools and is carried through the line, it deposits moisture, which, if carried into the pneumatic tools using the air, interferes with their proper operation. Much of the trouble with water in the air line can be overcome if small air receivers to act as collecting chambers are placed in the line at frequent intervals; otherwise, moisture traps should be used.

Moisture traps can be purchased today as manufactured articles but good results can be obtained if they are made of pipe fittings, consisting of tees set in the pipe line at frequent intervals, the tees having a pipe leg hanging down to the drain connection at the bottom. The tee and drop leg should be made of pipe several sizes larger than the pipe line.

All filters require a certain amount of cleaning, therefore it is important that the filter be located where it is easy of access. Inlet pipes are usually made of standard steel pipe or sheet metal pipe. The inlet should be as short and direct as possible. If extended any distance, it should be enlarged and usually the larger the better to keep down friction losses.

INTAKE AND DISCHARGE PIPING

If the intake is buried underground, it must be water tight as water from a water soaked soil or rain



TWO 2-CYLINDER MOTOR-DRIVEN COMPRESSORS IN A NEWSPAPER PLANT, SHOWING PIPING, RECEIVER, SAFETY VALVES AND AIR FILTERS

water must not be allowed to creep in. Glazed vitrified sewer pipe makes a convenient material to use for underground air intakes, as long sweep elbows of the same material can be obtained. If a concrete duct is built to use as an air intake, it must have a smooth hard interior surface, for if it crumbles due to air rushing through, the ingredients are carried into the compressor cylinders and rapid wear results.

Discharge piping should be the full size of discharge opening or larger and as direct as possible to the receiver or aftercooler. If elbows are used, they should be of long radius type. It sometimes happens that a discharge line is of such length between the compressor cylinder and the first elbow that a pulsation is set up which directly opposes the pulsation of the air as it leaves the compressor cylinder. Where this is the case, a much higher discharge pressure is necessary and is shown on the indicator card. This, of course, results in excessive horsepower and either the length of the pipe or its diameter should be changed, or a tee installed in place of an elbow with a straight piece of pipe some 6 or 8 ft. long with a capped end in line with the com-

*Engineering Department, Sullivan Machinery Co.

pressor discharge. This forms an air cushion and destroys the pulsation. The discharge line is continued from the side outlet of the tee.

All hose connections to air tools should be taken out of the top of the distributing line to avoid carrying any moisture to the tools. Whenever collecting tanks are used, they should be drained at frequent intervals.

One of the best ways to get rid of oil and moisture is by using an aftercooler, so that the moisture in the air will be condensed and deposited before it passes to the pipe line. Modern plants use an aftercooler and set it between the compressor and the air receiver. The aftercooler should be set indoors so that there is no danger of the water freezing, as these coolers employ circulating water as the cooling medium.

Air receivers serve to equalize the discharge pulsation from the compressor, and to deliver a steady flow of air to the service lines. The cubical contents of receivers as regularly used are from 1/6 to 1/10 of the free air capacity per minute of the air compressor used therewith. As large air receivers prevent rapid pressure fluctuation, it is best to be liberal in the size of air receiver used. Receivers should be made to A.S.M.E. standards, and most of the states insist on this standard.

Spiral Case Deflector for Flow Recording

PROPER LOCATION OF PIEZOMETERS FOR ACCURATE FLOW MEASUREMENT. BY I. A. WINTER*

FOR RECORDING FLOW of water through a hydraulic turbine, an ingenious device has recently been developed. This device consists of two piezometer connections located at an angle of 45 deg. with the longitudinal center line of the unit. One piezometer is at inner wall of the scroll, about 6 in. from its connection to the speed ring. The outer piezometer is located on the center line of the speed ring on the outer wall of the scroll, both the inner and outer connections being on the same radial line from the center of the unit.

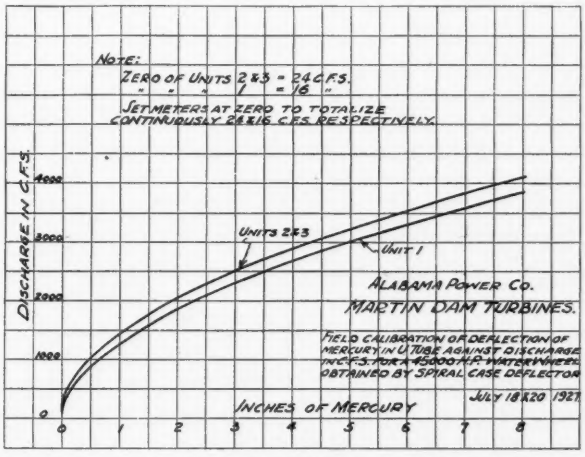
Experiments showed that this location gave the maximum differential pressure in the scroll and that the variation would be sufficient to actuate a mechanical flow recorder. It was also found that it was possible to design the installation of piezometers from the scroll case drawings and amount of water used by the turbine.

Other points brought out by these experiments showed that, although only three-fourths of the water to the wheel was being measured by the piezometers, it was a perfect indication of the complete performance of the unit. They showed also that, if the inner piezometer was located correctly, the angle of the turbine gates did not affect the differential pressure for a given rate of flow. This is of considerable importance where the head varies an appreciable amount during operation.

APPLICATION OF DEVICE TO A 45,000-HP. UNIT

Accompanying curves show results obtained during tests on a 45,000-hp. wheel under 145 ft. head. The deflection of mercury in a U-tube plotted on log paper against flow in cubic feet per second gives a straight line. This makes possible the use of a standard register for totalizing the flow of water through the wheel. It will be noted that the deflection of mercury for a given rate of flow was different for Units No. 1 and 2, whereas Units No. 2 and 3 are identical. This is because of the two designs of scroll cases used at this point; Units No. 2 and 3 are identical wheels and cases, whereas No. 1 is of different design.

An interesting feature of this device is that for a plant with a variable head it is possible to make a new operation curve at any time that the change in head justifies it. The location of the piezometers is such that the pressure waves in the penstock reach the piezometers at the same instant, thus giving a steady mercury column and permitting great accuracy in reading the rate of flow. With a register of reliable make connected to the deflector, it is possible to indicate, record and totalize the flow of water through the wheel and obtain the overall daily operating efficiency by a simple bookkeeping process.


NOTE:
ZERO OF UNITS 2&3 = 24 C.F.S.
" " " 1 = 16 "
JET METERS AT ZERO TO TOTALIZE CONTINUOUSLY 24 & 16 C.F.S. RESPECTIVELY.
DISCHARGE IN C.F.S.
4000
3000
2000
1000
0
UNITS 2&3
UNIT 1
ALABAMA POWER CO.
MARTIN DAM TURBINES.
FIELD CALIBRATION OF DEFLECTION OF MERCURY IN U TUBE AGAINST DISCHARGE IN C.F.S. FOR A 45000-H.P. WATER WHEEL OBTAINED BY SPIRAL CASE DEFLECTOR
JULY 18 & 20 1927
INCHES OF MERCURY
0 1 2 3 4 5 6 7 8

FIELD CALIBRATION OF DISCHARGE OF 45,000-HP. WATER WHEEL OBTAINED BY SPIRAL CASE DEFLECTOR

Devices of this kind must be calibrated by some recognized method of water measurement at the time of test of the unit. This device in no way gives an approximation of the rate of flow through the wheel sufficiently close for test purposes but, when calibrated with a reliable method of water measurement, it does indicate rate of flow sufficiently accurate for any purpose.

BRIEF DISCUSSION of the more obvious differences between British and American coals is given in Technical Paper 446, recently issued by the United States Bureau of Mines, Department of Commerce. A factor that should be seriously considered, apart from the possibility of differences because the flora and conditions of decay may have been different, is the change due to the earth movements to which the coal has been subjected, particularly in relation to differences in the state of coalification which the mass of original vegetable matter may have reached before the earth movements occurred, state Reinhardt Thiessen and Wilfrid Francis, the authors.

*Alabama Power Co., Birmingham, Ala. Abstracted from a report of the Hydraulic Power Committee, N. E. L. A.

All This Boiler Is Superheater*

EVAPORATION IS BY SUPERHEATED STEAM AT 1700 LB. IN THE LÖFFLER BOILER. BY JAROSLAV HAVLICEK

EXTREME pressures and temperatures are used at all points in this plant, which is in the nature of a large commercial trial but based on long runs and experimental tests of smaller units. Boiler and turbine operated at 1700 lb. and 932 deg., economizer working at 1700 lb. and heating water from 252 deg. up to 527 deg., air preheated to 572 deg., all evaporation in non-fired drums by means of mixing superheated steam with high-temperature water and reheat of steam at 210 lb. to 662 deg. by live, superheated steam are among the unusual features. Also all circulation in fired sections is forced by pumping so that velocity, hence heat absorption, can be regulated according to the load carried.

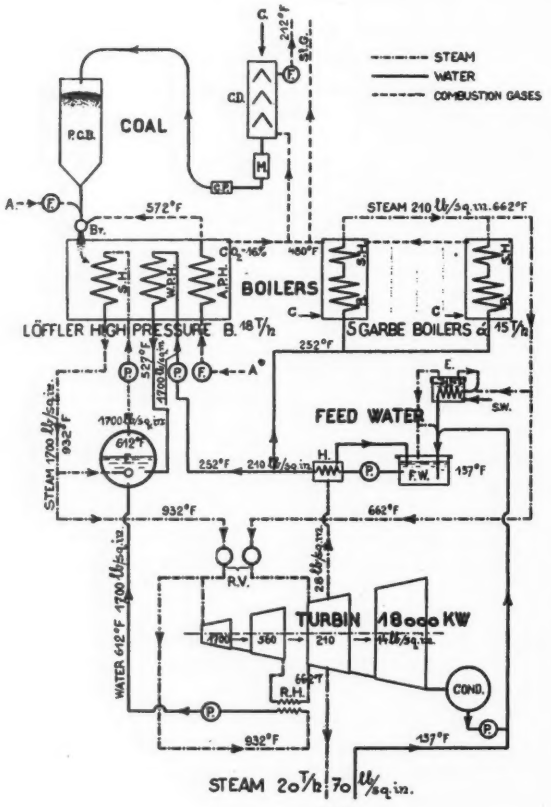


FIG. 1. DIAGRAM OF ARRANGEMENT AND CONDITIONS OF WITKOWITZ 1700-LB. PLANT

CAPACITIES OF UNITS

Designed for 18,000 kw. at 3000 r.p.m., the four-stage turbine will require 132,000 lb. of steam an hour when all is supplied at 1700 lb. and 932 deg. At present, a boiler unit for 39,600 lb. an hour is operated, with two other units for 88,000 and 110,000 lb. an hour under construction. Steam at 210 lb. is supplied to the last two stages from the existing 210-lb. boilers at present and, when completed, a small amount of steam will be supplied at that pressure from waste heat of a nearby coke plant.

Stage pressures, as shown in Fig. 1, are 1700, 560, 210 and 14 lb. absolute initial, with exhaust to 0.7 lb. Bleed points for industrial steam at 42 to 70 lb. and for heating condensate at 28 to 42 lb. are located in the third stage. First and second stages furnish 6000 kw., the third and fourth 12,000 kw. all being coupled on one shaft which carries the generator.

Surface of 23,670 sq. ft. is provided in the condenser, which uses recooled water, and feedwater is made up of condensate, returns from industrial and stage heaters and distilled water from a 210-lb. live steam evaporator.

Useful work of the turbine is calculated as 37.6 per cent of heat supplied and heat per kilowatt-hour output as 10,800 B.t.u.

FUEL, WATER AND STEAM CIRCUITS

These are shown diagrammatically in Fig. 1. Fuel is a mixture of coke waste, coal washings and pulverized coal, with 25 per cent ash content and heat value of 10,800 to 11,160 B.t.u. It is dried from 15 per cent to 1 per cent moisture in coal dryer CD by flue gases, then ground in Fuller mills to a residue of 12 per cent on a 180-mesh screen and stored in concrete bunkers, from which it is delivered by Fuller-Kinyon pumps to the bin PCB above the boiler.

By primary air it is blown to five vertical burners, secondary air at 572 deg. being forced in through the air preheaters, F of Fig. 2. Gases pass over radiant superheater B and convection superheater D of Fig. 2, then to economizer E and air heaters F to a 210 lb. Garbe boiler which acts as an extra economizer.

To the hot well are taken condensate, heating returns and distilled make-up, having an average temperature of 157 deg. A feed pump passes the water through a stage heater which heats to 252 deg., part of the water going to the 210-lb. boiler, the balance to a second pump which feeds through the 1700-lb. economizer, delivering at 572 deg. to the evaporator drums, E of Fig. 1 and A of Fig. 2, no steam being made in the economizer.

Into these evaporator drums, steam at 1700 lb. and 932 deg. is blown, mixing with the water and evaporating part of it to steam at 1700 lb. and 612 deg., which is forced by a reciprocating circulating pump to the superheater sections, which raise the temperature to 932 deg.

From the superheater, steam goes three ways, two-thirds to the evaporator, one-third to the turbine and to the reheater below the second stage, from which condensate is returned to the evaporator drums.

Electric drive is used for all present pumps but, for the additional boilers, feed and circulating pumps will be turbine driven, each estimated to require 9.6 B.t.u. per pound of steam generated.

*Abstracted from Mechanical Engineering.

Evaporator drums, five in number, 31.5 in. diam. by 22 ft. 9.5 in. long are shells forged and turned, with flat heads screwed in the shell ends reinforced by rings shrunk on after the heads are screwed in place. All openings and connections are made in the heads.

Construction Is Kept Inexpensive

Radiant superheater tubes are 1.75 in. inside diameter and ⅜ in. thick of bent tube form connected to headers. The convection superheater with tubes 2.17 in. inside diameter and 0.41 in. thick, also the economizer with tubes 1.58 in. inside diameter by 0.21 in. thick are of nine tubes each, which are bent in figure 8 and connected in parallel. Pipe joints are made by autogenous welding, annealed, the material of all parts being Siemens open hearth steel of 85,000 lb. tensile strength and elongation 18 to 20 per cent.

Horizontally-split housings are used for the turbines,

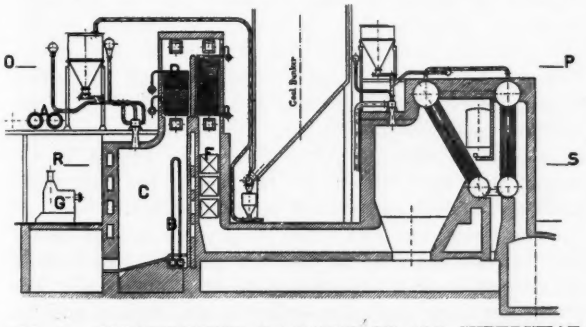


FIG. 2. ARRANGEMENT OF PARTS OF ALL SUPERHEAT STEAM PLANT

cast steel for the first and second stages and cast iron for the other two.

At present, all 1700-lb. steam made is used and governing is by control of 210-lb. steam admitted to the third stage. When full supply of 1700-lb. steam is available, all the 210-lb. steam coming from the coke works will be used and governing will be by throttling the 1750-lb. supply, which is admitted through six valves, arranged in pairs and opening one after another.

Learned from Operation

Too small a feed pump suction and arrangement of steam and feed lines which resulted in vibration were early remedied but frequent repacking and tightening of circulation-pump stuffing-boxes on the 1700-lb. reciprocating pump are found necessary. For the new units, these will be of centrifugal type.

After 3000 hr. of operation, pumps, furnace, superheater tubes and turbine are found in good condition. Some soft sludge accumulates in the evaporators but is easily flushed out. Tubes of the radiant superheater accumulate a porous layer of ash after a few days but this sheds off as it becomes thicker so that it does not accumulate. Slag glazes the upper third of the furnace walls but lower down forms stalactites or spongy formation which drops or is cleaned off. Granular ash is deposited at the bottom of the furnace and is removed every two days. Absorption of heat by the radiant superheaters keeps the temperature of the chamber down to 2200 deg. at a point slightly below the burners and thus favorable conditions are maintained.

Leakage of cooling water into condensate, due to cracked or loosened condenser tubes has caused some deposit of salt on turbine blades in the first stage, in reducing valves and at flange leaks but the salt at about 612 deg. F. seems to become sublimated with the water so that deposit occurs only where condition of the steam changes due to throttling or condensation. No corrosion has been caused and correction of condenser leakage would, of course, prevent all deposits.

P. G. & E. Co. Install 134,000 hp. of 1400-lb. Equipment at Station A

By C. W. Geiger

AS A PART of the Pacific Gas & Electric Co.'s construction program for 1929, extensive additions will be made to the equipment in Station A, San Francisco. Turbine generators of a capacity of 134,000 hp. with accompanying boilers and auxiliaries will be installed, doubling the capacity of the existing plant and making possible many operating economies.

New equipment will include two 67,000-hp. cross-compound turbine-generator units, each consisting of a high pressure section of 16,000 hp. operating at 1200 lb. per sq. in. throttle pressure, and a low-pressure section of 51,000 hp. at pressure of 400 lb. per sq. in. The high-pressure sections make 3600 and the low-pressure 1800 r.p.m.

To give space in the existing building for these new units, it will be necessary to remove two 27-yr.-old reciprocating engines of 4700 hp. each, one rather obsolete vertical turbine of 16,000 hp. and one of 20,000 hp. The net capacity of the station, after the completion of the new construction will then be 174,000 hp. Space required for the 45,000 hp. of old units being removed is more than sufficient for the 134,000 hp. of new turbines being installed.

These new units will require three new boilers operating at about 1400 lb. pressure. Owing to the size of these boilers, the boiler room will have to be extensively reconstructed and the roof suitably raised.

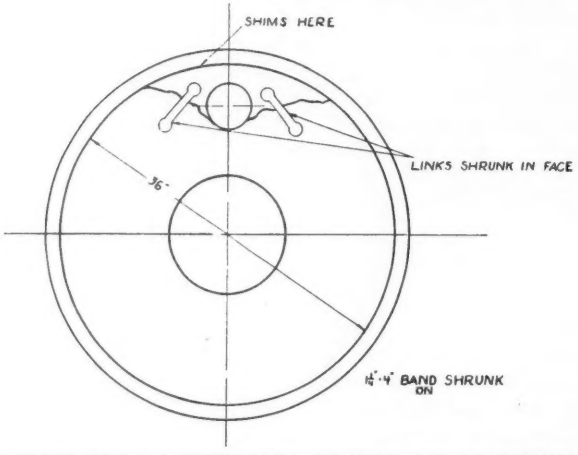
Air heaters, feedwater heaters, steam reheaters and the like will be installed. Air entering the combustion chambers will be preheated to 500 deg. Feedwater will be heated to 425 deg. by steam bled from the turbine units. Steam which has passed through the high-pressure turbine will be reheated, before entering the low-pressure unit, to 750 deg., by steam reheaters.

So large an increase in generating capacity calls for a corresponding reconstruction of the electrical switching equipment and the controls centered in the switchboard. A new sound-proof switchboard room, elevated to give a commanding view of the entire generating room, will be installed.

Sales of mechanical stokers for March, 1929, as reported to the Department of Commerce by the ten leading manufacturers in the industry, totaled 117 stokers installed under boilers of 42,432 hp. capacity as compared with 80 stokers under 31,554 hp. in February and 123 under boilers of 43,425 hp. in March, 1928.

Air Compressor Emergency Repair

SOME TIME AGO the large cross-compound, two-stage air compressor which furnishes air to a large railroad repair shop came to a sudden stop with a tearing crashing sound. Examination showed that a large piece of the crank disk carrying the crankpin had broken out



FORCES DUE TO SHRINKAGE OF IRON AID IN REPAIR OF CRANK DISK

and further examination disclosed the cause of the accident.

When the cylinder head of the high-pressure cylinder was removed, we found the piston nut with the end of the rod broken off, in the air cylinder. This rod had evidently broken off when the piston was almost at the end of the stroke, as it was caught between the piston and the cylinder head just below center. The impact was so severe that the piston rod was driven through the piston head bursting the piston and spreading it with such force that it became wedged in the cylinder. The piston was fitted to the rod by a taper fit held on by a large nut.

As this compressor was the only one at the plant and as it would have required several weeks to obtain repair parts from the factory, it was decided to make temporary repairs as soon as possible. The first step was to find a piece of cast iron large enough to make the piston. This was found in a local foundry and promptly machined. Repair to the crank disk was the major item in making the repairs. After consultation, it was decided to shrink a band on the crank disk, so a band was forged out of 1¼ by 4-in. iron. This band was then bored ¼ in. smaller than the disk, as it was desired to secure all the pressure due to shrinkage possible. After heating the band, it was placed around the disk and shims were placed over the part of the disk which had broken out. After the band had cooled, it was decided to shrink draw links into the face of the disk on each side of the pin. These links were made as shown in sketch. After they were heated in the center, they were driven into the face of the disk which had been drilled and slotted to receive them.

The piston rod was removed, a piece welded on the end and machined to fit the new piston. After about 10 hr. hard work, the repair job was completed. The crank now is as strong as before it was broken and the crankpin is absolutely tight.

Birmingham, Ala. E. O. EDNEY.

Steam Pipe Vibration

ELBOWS CAUSE VIBRATION in Steam Pipes, as printed on page 197 of the February 1 issue, has proved very interesting to me because of a number of experiences the company with which the writer is connected has had during the past several years as manufacturers of control specialties, particularly on water service. Our company had a number of installations on which more or less severe water hammer and line agitation has resulted, apparently due to the installation of specialties such as float or level controls and reducing valves and where the trouble has reflected somewhat on our equipment.

These experiences have led to certain conclusions, one being that frequently there is a local condition which causes such line reaction under certain conditions of flow which we have arbitrarily termed "critical conditions of flow." From observation, there are several causes for this condition: 1, air pockets in the line; 2, complicated piping, usually due to a number of 90 in. elbows and loose lines; 3, lines that for one reason or another prove to be too small and in which velocity at certain points becomes so great that the fluid in the line apparently separates causing vacuum pockets, which, when they reach the point of collapse, create shocks depending upon the number and sequence of the collapse of one or more vacuum pockets in the line of flow.

Observation has shown that such reactions primarily occur on the inlet side of the specialties. This is

perfectly natural where float or level control specialties are involved but is somewhat unexpected in connection with reducing valves unless one has had some experience with the condition. We have found in connection with reducing valve installations that the trouble or reaction starts on the inlet side and carries through the reducing valve quicker than the valve can readjust its position, which indicates a similar reaction on the reduced pressure side with the valve responding to the reaction serving as an amplifier and thus actually in some cases aggravating the condition, for which it is primarily not responsible.

With increasing pressures of modern engineering practice and increasing use of automatic equipment, it is becoming more necessary that designing engineers give proper consideration to the character and design of pipe lines in which specialties are to be used in order to eliminate such difficulties which, in some cases that we have known, have proved almost unsolvable after the job is completed.

It may also be of interest to know that in some cases where we have completely removed the internal parts of specialties or completely cut them out of commission, that similar pipe line reaction could be obtained by the throttling of gate or globe valves to duplicate the critical flow conditions involved.

Philadelphia, Pa. F. H. JONES.

Engine Vibration and Shock

VIBRATION, PARTICULARLY in oil engines, is caused by lack of balance, therefore, engines are usually carefully tested for this before leaving the factory. Vibration should not, therefore, develop in operation but it may do so through inadequate engine foundations. Vibration may be transmitted from coupled shafting or caused by unbalanced load on different cylinders of a multicylinder engine. Foundations should always be built upon or tied to solid ground. If vibration is caused by inadequacy of the foundation, the latter may be increased in weight. Increasing the weight on the engine bedplate by filling it with concrete or lead may provide a partial remedy.

Vibration may be transmitted from coupled shafting under impulsive load, in which case it is advisable to connect the two shafts by a flexible coupling. More serious is the likelihood of torsional vibration of the crankshaft, as this may develop where shafting is driving smooth running machines such as electric generators. Torsional vibration has, in the past, led to many crankshaft fractures and tests are now made for this vibration on the test floor.

When an engine is direct connected to other shafting, its critical speeds depend, not on the engine crankshaft alone but also upon all of the connected shafting. Therefore, although there may have been no torsional vibration on the test floor, such vibration may develop later, even if the connection is to a single machine such as an electric generator. This difficulty is often overcome by connecting the two shafts by a flexible coupling. When torsional vibration exists, a crankshaft may fracture as it passes through its critical speed. Sometimes an engine will vibrate violently as it passes through or is running at a certain speed; such speeds should, therefore, be avoided.

Crankshafts may fracture due to overstress caused by preignition, by a slack flywheel key or by misalinement of the shaft. When preignition occurs in an engine, the whole line on which it occurs is strained and the shock is transmitted to the crankshaft. Such shocks as are caused by leaky fuel valves and preignition may throw severe stresses on the crankshaft sufficient to cause it to fracture. When a flywheel has a loose key, the crankshaft is subjected to a series of shocks during each rotation. Keys should be carefully fitted so that they bear their entire length in the keyway. No packing should be used between the key and keyway but, if the key is not a tight fit, a new one should be fitted.

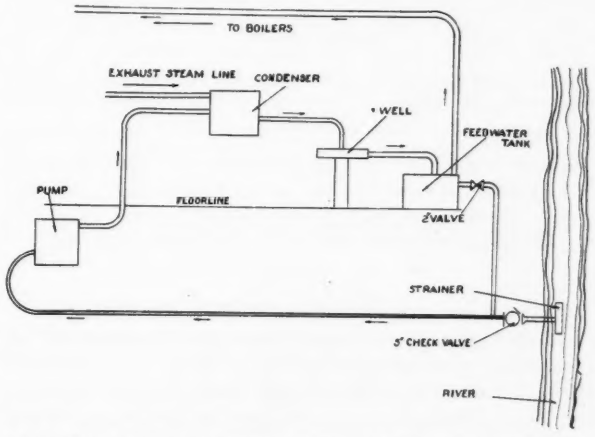
If the flywheel is loose on the shaft, it may be secured by adding a saddle key at right angles to the key already fitted to the shaft, taking care that the wheel is not thrown out of balance thereby. A shaft out of alinement is continually under varying strain and many fractures have occurred through this cause. A sign of misalinement is persistent overheating of the shaft bearings and an endwise movement of the flywheel.

Brentford, England. W. E. WARNER.

Condensate Overcomes Steam Making Trouble

WE HAVE A 225-hp. Corliss engine operating condensing and carrying 20-in. vacuum. We use the condensate for our three Bigelow boilers.

We had a hard time keeping up steam because the feedwater, which was only 65 deg. F., was too cold.



ARRANGEMENT OF EQUIPMENT AND LINES SHOWING HOW CONDENSATE IS RETURNED TO FEED LINE

Our feedwater tank holds 18,000 gal. of water, so I ran a 2-in. pipe from it to the 5-in. suction pipe, connecting it in at the riser intake. In this 2-in. pipe I installed a 2-in. valve, thus permitting the flow of water from the tank to the 5-in. line, to be regulated.

The 2-in. valve is left open until the feedwater has a temperature of 130 deg. after which the valve is regulated to maintain this temperature. If the temperature should be allowed to get too high, the suction would be broken.

Through this arrangement I raised the feedwater temperature from 65 to 130 deg. and have no further trouble in keeping my steam pressure in the three boilers.

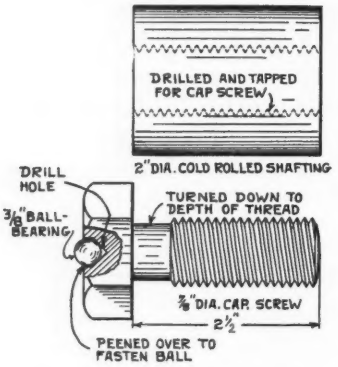
Seymour, Conn. CHARLES MEHR.

Simple Jack Works in Limited Space

LIMITED SPACE only is often available for the application of a jack. A jack which satisfies this condition and at the same time is powerful is illustrated herewith. This jack is made of a piece of 2-in. cold-rolled shafting about 2½ in. long. This piece is drilled and tapped for a ⅞-in. screw.

A hexagon cap-screw of the corresponding diameter and length is then turned down at the shoulder to a diameter slightly less than that of the bottom of the thread and the center of the head drilled out for the reception of a ⅜-in. ball bearing. The depth of the hole should be such that the ball enters the hole more than halfway. The edge is then peened down tight so that the ball is held rigidly.

Two of these jacks have been used to lift a 5-t. load. The ability of such a jack to be used in a limited space,



COLD ROLLED SHAFTING, AND CAP SCREW WITH BALL BEARING IN HEAD FORM HANDY JACK FOR LIMITED SPACE

is best shown by the fact that one has been used to straighten out a short kink in the front axle of a Ford car without necessitating the removal of the axle.

Oregon City, Ore. G. B. PHILLIPS.

Value of Waste Wood as Fuel

I RECENTLY RECEIVED the following inquiry regarding the value of waste wood as fuel: "Will you kindly inform me regarding the relative heat obtained from a ton of run-of-mine coal, compared with a cubic yard of mixed kiln dried sap gum and poplar blocks and strips such as usually come from the cutoff and rip saws. I am debating the question whether to sell these refuse blocks or burn them. By the time these refuse blocks are burned, they would contain about 7 per cent of moisture."

It was impossible, of course, to reply accurately to the foregoing questions because the exact proportion of sap gum and poplar blocks were not stated, nor did he give the exact sizes of the pieces. I presume the sizes vary considerably, so that he could not give the exact proportions and sizes even if he wanted to do so.

Therefore I had to do some estimating to work out the problem. We have a few facts to start out with. Wood with 45 per cent moisture gives only 50 per cent as much heat as dry wood. Rosin increases the heating power by about 12 per cent. According to Roth, 100 lb. of wood, as sold in wood yards, contains 25 lb. of water, 74 lb. of (dry) wood and 1 lb. of ashes. Thus, 100 lb. of green wood (50 per cent moisture) will furnish about 270,000 B.t.u., 100 lb. of air-dry wood (10 per cent moisture) about 580,000 B.t.u., and 100 lb. of kiln-dry wood (2 per cent moisture) about 630,000 B.t.u. Hence, my suggestion to him was that he weigh a cubic yard of his scrap dry lumber, divide it by 100, and then multiply by 600,000 B.t.u., which is a value roughly interpolated between the 580,000 and 630,000 values. The result will be the approximate B.t.u.'s in a cubic yard of his waste wood.

A cubic yard of solid poplar weighs about 30 lb. I would estimate, on the basis of 40 per cent solid wood, that a cubic foot of waste poplar would weigh about 12 lb. in which event a cubic yard would weigh 27 × 12 = 324 lb. Applying the above rule, we now have:

$$\frac{324}{100} \times 600{,}000 = 1{,}944{,}000 \text{ B.t.u. per cu. yd.}$$

A ton of run-of-mine coal varies in heat value depending upon the kind of coal but let us take a typical coal which, when dry, has a heat value of 13,192 B.t.u. per lb. Bituminous coal weighs about 52 lb. per cu. ft. or 1400 lb. per cu. yd. It would, therefore, have a heat value of about 18,470,000 B.t.u. as compared with my estimate of 1,910,000 B.t.u. per cu. yd. of waste lumber.

In other words, on the basis of heat value per cubic yard, I estimate that the waste wood has a heat value of about one-ninth or one-tenth that of coal.

Newark, N. J. W. F. SCHAPHORST.

Circular Rip Saw Cuts Copper Well

COPPER IS DIFFICULT material to machine or to saw by hand. To reduce the width of a copper bus bar that is several feet in length, is, as a rule, a tedious job.

This, however, can quickly and neatly be done by a carpenter's circular rip saw. A saw of about 8 in. dia. with teeth about an inch apart and operating at the usual peripheral speed, about 5000 ft. per min., does very well. The teeth should have square chisel points. The tips of the teeth should project through the cut only a short distance, a rule that is also good when ripping wood.

It is advisable to wear goggles to protect the eyes from particles of copper.

Long Beach, Calif. E. J. JORDAN.

MOHAWK-HUDSON POWER CORP., Albany, N. Y., operating the New York Power & Light Corp., same address, and other utilities, is arranging an expansion and improvement program in 1929 to cost about $8,000,000. A large portion of the fund will be used for extensions and betterments in existing power stations, with installation of additional equipment for increased output. A single major project is planned in connection with a new hydroelectric generating station at the Conklinville dam, Conklinville, to take advantage of the power possibilities of the development; this plant is expected to cost close to $500,000, while an additional $200,000 will be expended for transmission lines, switching stations, power substations and incidental work. Plans for another hydroelectric power project at Hadley, under advisement for some months past, will still be held in abeyance, and no construction is contemplated at the place during the present year.

Questions and Answers

Flow Measurement Over Weirs and Dams

WHAT IS THE formula for measuring the flow of water over a weir or dam? J. K.

A. Weir measurement by large quantities of water is usually done by means of a rectangular shaped sharp-edged weir, in which case the formula $Q = 3.33 (b - 0.2 h) \sqrt{h^3}$ may be used, where: Q = quantity of water discharged, cu. ft. per sec; b = breadth weir in ft.; h = head in ft. measured from the level of the weir crest to the level of still water above the weir.

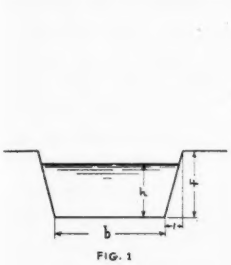


FIG. 1

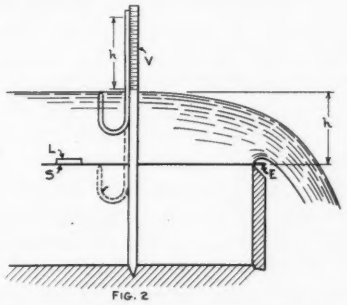


FIG. 2

FIG. 1. TRAPEZOIDAL WEIR WHOSE TAPERED SIDES AVOID NECESSITY OF CORRECTING FOR END CONTRACTIONS

FIG. 2. TYPICAL METHOD OF MEASURING THE HEAD ON A WEIR

For a V-notch weir, the formula is $Q = C (8 \div 15) \sqrt{2 g h^5}$, where C = coefficient of discharge depending upon the angle of opening, an average value for C being 0.592, when the formula becomes $Q = 2.53 \sqrt{h^5}$.

For a trapezoidal weir, in which the slope of a side is 1 to 4 as shown in Fig. 1, the formula becomes: $Q = 3.33 b \sqrt{h^3}$.

Measurement of head on the weir is obtained by means of a hook gage, Fig. 2, which consists of a sharp-pointed hook attached to vernier scale V intended to measure accurately the amount that the hook is moved. Before taking an observation, the hook must first be so adjusted that it is at the exact level of the bottom edge of the weir. This is done by means of a straightedge SE and a level L placed upon the hook and edge of the weir. This height on the scale is called the zero head. It must be subtracted from all other readings to obtain the head of water flowing. To obtain an observation, the hook is first submerged and then raised until the point just breaks the surface of the water. The hook gage must be placed in a position on the upstream side of the weir where the surface has no appreciable velocity and where there is little disturbance due to eddies.

Flow of water over dams varies from about 20 per cent less to 20 per cent more than for a sharp crest of the same length and with the same head. For broad, flat-crested dams, with the flat top wider than the head, the coefficient 2.64 instead of Francis' 3.33 applies in the formulas or with sufficient accuracy, the discharge is 80 per cent of that given by the Francis formula. If the upstream corner is rounded, the discharge may be greater. Dams with steeply sloping up-stream faces (about 1 to 1) may have coefficients nearly as high as 4, as will also a thin vertical bulk head with a rounded up-stream corner (radius = 2 to 8 in. = thickness of bulk head).

A very gradually sloping approach, e. g., 5 horizontal to 1 vertical, or a rounding crest of large radius, introduces an appreciable friction effect and the discharge may be no greater than for a sharp-crested weir.

Non-vertical up-stream faces on sharp-crested dams increase the discharge if inclined down-stream and decrease it if inclined up-stream, the coefficient being 3.10 for a 1 to 1 up-stream and 3.73 for a 2 horizontal to 1 vertical down-stream inclination; coefficients for intermediate inclinations are between these values. If air is not allowed free access under the falling sheet of water at the crest, the discharge over any narrow-top weir or dam is increased but is also made less certain, due to the tendency of the partial vacuum so formed to break at intervals and cause pulsating flow.

Piping Change Reduces Compressor Noise

WE HAVE a 6 by 6-in. automatic, electrically-driven air compressor whose air receiver is located in our shipping room. The noise of the valves which is communicated to the receiver is disturbing. Is there any way to stop or reduce this noise? F. M. S.

A. Sometimes a vibration is set up in the air line which can be cured by changing the piping layout. Only a slight change is necessary or, if you prefer, you could try taking out a small section of the line and installing a slightly larger diameter pipe in this particular section. The object is to change the sympathetic period of vibration of the pipe so that it is different from the rate of impulses of air.

Positive Cutoff Valve Gears

WHAT IS MEANT by positive cutoff? A. J. F.

A. Engine valve gears that are known as positive cutoff are those which do not release the valve from the gear at the point of cutoff. The term "positive cutoff" is regularly applied to the "four-valve" engine or so called "non-releasing Corliss" engine.

Editorial Comment

Are We to Have Industrial Central Stations?

Recently, a prominent public utility engineer, while discussing the modern trends of power plant design, called attention to the fact that several of the public utility companies, in selecting sites for new stations, have, wherever possible, bought large tracts of land surrounding the station sites.

This has been done, according to this engineer, not merely for the sake of owning more property but rather with the idea that there is a possibility of eventually attracting to the neighborhood of these stations a number of industrial plants with diversified demands for steam, electric power and other services. The object of such an arrangement would be to permit the central station to supply to each of these industrial plants, in addition to the necessary electric power, just the amount of process steam, hot or cold water, compressed air and possibly even refrigeration, that would be required for each plant. These services, from the standpoint of the central station itself, would be designed to utilize to the fullest extent an aggregation of equipment which is perfectly capable of producing them in addition to the making of electric power, thus increasing the economy of the entire station. From the standpoint of the industries, these services would be supplied to them as so many commodities entering as raw materials into their processes.

It goes without saying that any such scheme would have to be based on a most carefully worked out engineering heat balance and financial balance. That is, there would necessarily be a point beyond which the amount of steam, water and so on that could be furnished to the industries would be uneconomical if the power plant were still to function as a central station, supplying power to its transmission system.

Furthermore, the industries would have to be more or less hand-picked, so that the total load for steam and other services would remain fairly constant. One plant might need lots of hot water and steam and only a small amount of power; another might need a great deal of water and power and only a little steam. It is obvious that only industries whose requirements would balance could be selected.

What this scheme really means is the block plant, which is nothing more nor less than a small central station designed for a group of plants. Yet, in spite of the many advantages claimed for the block plant idea, it has seldom been tried. There are, of course, several central stations serving district heating systems with exhaust steam from their prime movers but that is not the same thing. The nearest thing to the block plant we know of is employed by two former breweries which rent some of their buildings to outsiders and supply them with all power and allied services. The Pabst Corp. at Milwaukee, described some time ago, is one of these. Yet this is not the same as the block plant, because the power plant in this case is owned by one company, instead of jointly by all of them.

Many central station engineers are interested in the industrial group idea outlined above on the ground that, if such an arrangement is economical for one industrial power plant requiring various services, it ought to be economical for a group of them.

A step in this direction appears to have been taken in the design of the new Deepwater station which will generate steam at 1400 lb. pressure, pass it through a high-pressure turbine-generator and send the exhaust at about 400 lb. to a large industrial plant nearby. It will be interesting to note whether this is the beginning of a trend or whether it is only a special, isolated case.

It will be evident that the number of central stations that might be able to offer complete power plant service to a group of industries would always be somewhat limited by physical considerations, as would the number of industrial organizations that can take advantage of it. The principal obstructions seem to be financial rather than engineering details, as has been indicated recently by a consulting engineer who had such a plan all completed but was prevented by financial difficulties from carrying it out. It seems that there is only one way by which the worth of the industrial central station, if we may coin the expression, can be definitely determined. That is by actually building and operating such a station.

Increasing the Usefulness of Electricity to Humanity

Each day brings to light new uses for electricity, uses which a few years ago were not thought of, uses which increase and add diversity to the load of the power plant and help to even up the load throughout the day.

Experiments made with milk coolers showed that milk placed in tanks cooled by electric refrigeration units without stirring or aeration showed a bacterial count of 8000 to 11,000 per cubic centimeter as compared with 10,000 to 50,000 in tests when the cans were first aerated and placed in the cooler. In each case stirring the milk or aerating it showed a marked increase in the bacteria count. The less milk is handled and the quicker it can be cooled, the better the quality will be. Tanks cooled by refrigeration units best meet these requirements.

Again, in some European packing plants electricity is employed in slaughtering cattle. The method employed is similar to that employed in American prisons for executing criminals. An electrode is attached to the neck of the animal and another to the spine. Leg electrodes as used in our American prisons are omitted as equally good results are secured without them.

In the field of sports, electrically lighted fields have proved to be extremely valuable, not only for sports requiring small areas like basketball but for other sports like baseball and football where large fields must be lighted. Race tracks are said to be the latest innovation in this line, tracks having been lighted successfully in several American cities, thus enabling those who enjoy horse-racing but are kept at their work in the daytime, an opportunity to enjoy the evening races.

Already, after a short life of not much more than 40 yr., electricity is the biggest factor in our every-day life. But a small part of the total number of uses of electricity have been discovered. Each day adds to the electrically operated appliances available for our use and we have no reason to believe that the usefulness of electricity in meeting necessities and supplying luxuries has much more than started.

Off Duty

Our amazement never ceases when we contemplate the multitudinous activities of our government departments, particularly those of the Department of Commerce. As editors, we naturally are supposed to be very wise and in touch with all things in the Universe and are supposed to give expert advice off hand, on anything from our exports to the Virgin Islands to the behavior of disembodied electrons in the dark companion star of Sirius. Being halfway human and therefore quite vain, we sort of believe this ourselves and we permit the government bureaus to send us information on all manner of things. Thus it is, that in our morning's mail which is lugged in by three or four husky patriots, we are amazed to learn that the production of buttons has decreased 11 per cent during the year. To fellows credited with so much intelligence as we are, this news naturally is most disconcerting, for certainly if the number of buttons has decreased, the number of button holes likewise must have decreased. For what good is a buttonhole without a button? This, obviously, is a profound question and we begin to philosophize about it but no sooner do we get started when in comes another report from the D. of C., this time on the use of excelsior.

Once again there is bleak news; the production of excelsior last year dropped 1.6 per cent! This is terrible! Don't people realize the importance of excelsior any more? Have the breakfast food manufacturers found a new source of raw material? Has the world forgotten the epic poem of the immortal Longfellow about the brave youth who—

—bore, mid snow and ice,
A banner with the strange device,
Excelsior!

We never did know what this poem was about but Longfellow no doubt realized that excelsior was important. And now production has decreased. Instinctively we make a note of the fact (we are forever making notes). Something ought to be done about it but, of course, nothing ever will—there is so much to consider.

Here, for instance, is another survey—one on the production of artificial limbs but this time there is good news. Yes, indeed, the production of artificial limbs went up 6.4 per cent last year. Sad to relate, however, the power plant industry with which we are associated, gets no credit for this increase; all of it, apparently, is due to the splendid efforts of the automobile clubs. It seems, however, that the automobile drivers are too careless for instead of merely maiming their victims thereby establishing a market for artificial limbs, they kill many of them outright. Last year, D. of C. figures report 22.9 deaths per 100,000 population from automobile accidents against 21.9 per 100,000 in 1927. Evidently they are favoring the morticians as well as the wooden leg merchants.

This, however, is a morbid subject, so we file the report in the waste paper basket and direct our editorial attention to the import of strontium. What! you don't know what strontium is? Heavens! don't tell us that, but perhaps you are not to be blamed; we can't all be editors. Anyway, here is a report from the department of the interior bringing the joyous news that a deposit of strontium has been discovered in Arizona. Strange that it should have remained undiscovered for so many years! Perhaps it was due to the fact that nobody ever looked for it. Whenever anybody went to Arizona, the only thing they looked for was the Grand Canyon. Heretofore we always had to import a lot of strontium but now we are assured of a domestic supply. Gosh, what a relief!

But our joy is short lived. The next thing that strikes our eye is a report on Carriages and Wagons, including wheelbarrows and again we note a sad decrease in production. Wagons, it appears, are on the decline, production having decreased 25 per cent since 1925. Something is wrong, but what is it? Have the wagon makers lost faith in the wagon buying proclivities of the people of the republic? Steps should be taken to make the country wagon conscious. (We make another note—maybe we'll write an editorial on the subject.)

By this time, we feel quite blue. Nearly everything is on the decrease. Let's see, isn't there anything in this mess to cheer us up? Here is a report on the use of working clothing—true, this line shows an increase but why speak of work clothing? We never cared much for work. We get paid for what we are supposed to know.

Next is a story on the use of spark plugs. This, as one of our staff remarks, ought to be snappy but we ignore the wise crack—his is a low form of humor. Who cares about spark plugs anyway?

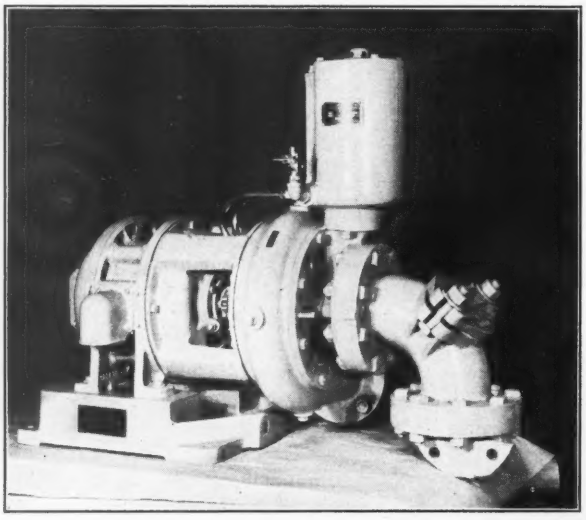
But, what have we here? "Our World Trade in 1928" issued by the Chamber of Commerce of the U. S. This is always of interest; our exports to Mozambique and Irak, and Tobago are so vital to our existence. Our exports went up 5.4 per cent last year and many notable records in our export trade were made. Take the matter of prunes, for instance. Last year we exported 267 million pounds of these things. Think of the happiness this must bring to our boarding house inmates, for every prune exported means just one less to consume at home.

And so it goes. Our solid mahogany desks creak under the strain of government statistics and our statistical editor is growing weary of life. He dreams of a heaven devoid of a department of commerce. The chances are, however, that he'll never get there. He swears too much.

Power Plant Engineering Developments and News

Jennings Suction Pump

TO PROVIDE quick and easy accessibility to a sump pump, the Jennings suction sump pump shown here has been developed. It is designed for mounting entirely above the sump so that only the suction pipe is



SUCTION SUMP PUMP

submerged. Pump and driving motor are built into a compact assembly and may be placed as convenience dictates either near to or remote from the pit.

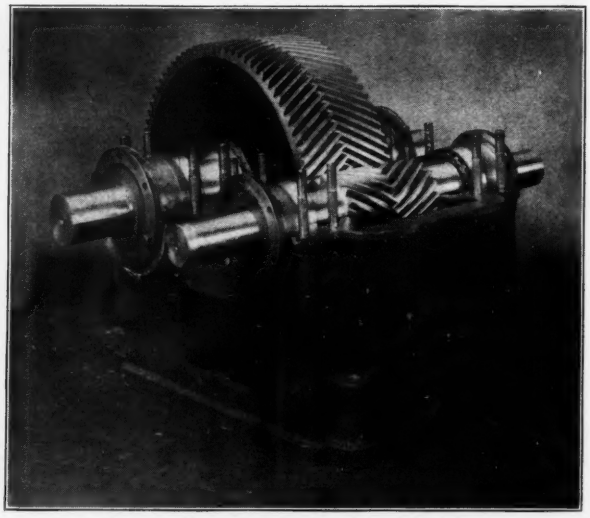
Jennings suction sump pump is essentially a self-priming centrifugal pump of the open impeller type, with only one moving element and no delicate wearing parts, for pumping seepage water and liquids reasonably free from solids. An open impeller is combined in the same casing with a vacuum priming pump. In operation, the priming pump exhausts air from the centrifugal casing and suction line and when the liquid reaches the impeller, the unit is designed to function as a simple centrifugal. In the entire assembly there are only two moving parts: the centrifugal impeller and the vacuum pump rotor, designed to rotate without contact and entirely free in the casing, with minimum wear.

In the Type A installation of the unit, where space is at a premium, the pump is placed at any convenient horizontal distance from the pit, with the pump connections and totally-enclosed, oil-immersed water-proof float switch below the cover of the pit, leaving its top clear. On the other hand, if space permits, the Type B installation is used, with the pump just at one side of the pit cover and the float switch mounted above the cover.

This suction sump pump is made by Nash Engineering Co., So. Norwalk, Conn., in capacities ranging from 30 g.p.m. at 15, 30, 45 and 60 ft. total head to 250 g.p.m. at 15, 30 and 45 ft. total head. Motor horsepowers range from ¾ hp. to 7½ hp. respectively, the smaller sizes operating at 3600 r.p.m. and the larger at 1800 r.p.m.

Speed Reducers with Herringbone Gears and Roller Bearings

COMPLETE SERIES of speed reducers, incorporating Sykes continuous-tooth herringbone gears and anti-friction bearings, is announced by the Farrel-Birmingham Co., Buffalo, N. Y. Improvements for this



HEAVY-DUTY TYPE REDUCER, SHOWING SYKES HERRINGBONE GEARS, TIMKEN BEARINGS AND BOX FRAME CONSTRUCTION

new design of units include Timken roller bearings designed to combine journal and thrust capacity, to hold pinion and gear shafts from end float and thus to protect them from abuse from connected mechanism. The manufacturer claims that this type of mounting is practicable with the Sykes gear, since the apexes of the teeth are central in the face of the gears around their entire peripheries and no end float of either gear or pinion is necessary.

Mechanical efficiency, it is stated, is increased to

between 98½ to 99 per cent for a single reduction and from 98 to 98½ per cent for a double reduction.

Lubrication is simple since, in all cases, the same oil may be used for gears and bearings and the splash and flood automatic system of lubrication is possible throughout the whole series.

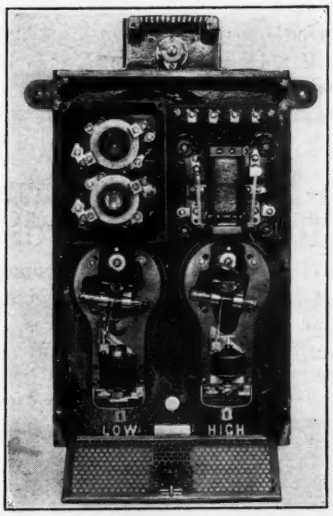
Since roller bearings are interchangeable, it is possible to make the gear units interchangeable and to manufacture them in larger quantities than the plain bearing type units, thereby reducing the initial cost.

Single reduction units are designed for ratios between 2:1 and 10:1 and powers between 3 hp. and 300 hp. Double reduction units are furnished for ratios between 10:1 and 60:1 and powers between 5 hp. and 200 hp. A heavy duty type unit, which has a strong box section and pedestal supports for the bearings, is supplied as illustrated for ratios from 1:1 to 10:1 and powers between 100 hp. and 400 hp.

For rolling mills, units are furnished for powers between 300 hp. and 5000 hp. The bearings are held in sleeves to facilitate adjustment and allow for shaft expansion. The case is of box section girder design, extending from the center line of the shafts to the base.

Duotherm Control for Unit Heaters

TO REGULATE room temperatures where unit heaters are installed and to provide for normal temperatures during working hours and lower temperatures during idle hours such as at night and on Sundays, a



DUOTHERM CONTROL WITH COVER REMOVED

Duotherm control, as shown here, has been developed. This consists of two thermostats with switches and accessories mounted in a cast aluminum box with cover and a separate push-button box with two buttons, one for high and low temperature.

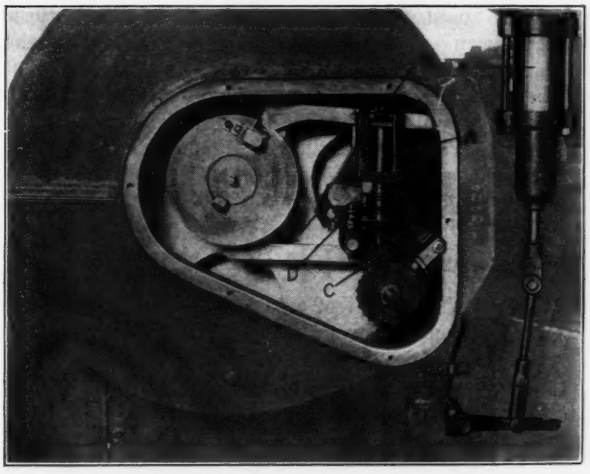
The object of this arrangement is to allow the thermostats to be connected into the motor circuits of the fan motors on the unit heaters, so that they will start and stop the fans to keep the temperature at the point at which the thermostat is set. Only one thermostat is in control of the motor circuit at a time, of course, therefore one thermostat can be set for normal room temperature, say 65 deg., to control under working conditions and the other for 45 deg. to control the fan motor under non-working conditions. To make this change from one thermostat to the other requires only the pushing of the corresponding button on the control box, which may be located in the boiler room, the engineer's office or other convenient point.

When several rooms are heated by unit heaters, the Duotherm controls can all be actuated by a master remote control button at one point. If one part of the room or building is to be used while the rest are shut down, the individual Duotherm governing that section can be actuated by its own push-button to put the high-temperature thermostat in control.

Adjustment of the thermostats is made through a hinged and locked drop panel, to prevent unauthorized adjustment that so often results in overheating. Also, when the high-temperature thermostat is governing, a bulls-eye signal light at the top of the box is illuminated. Suitable provisions are made for all necessary electrical connections. This Duotherm control is a product of Grinnell Co., 260 West Exchange St., Providence, R. I.

Automatic Control for Riflex Drive

SPECIAL CONTROL has been developed for automatically controlling the air and fuel supply when using the new Riflex mechanical drive recently devised for Jones stokers, as described in the March 1, 1929 issue of Power Plant Engineering. This control and stoker are intended to relieve the fireman of all duties except to keep the coal hopper filled and clean the fires two or three times a day by means of the dump plates. This control consists of a master valve, which may be located at any convenient place in the boiler room, connected by a quarter inch pipe to a small hydraulic power cylinder (F) located on the stoker drive, as shown. The master control valve, which is connected to boiler pressure, is actuated by a decrease or increase in the boiler pressure. This valve in turn controls the position of the piston of the power cylinder.

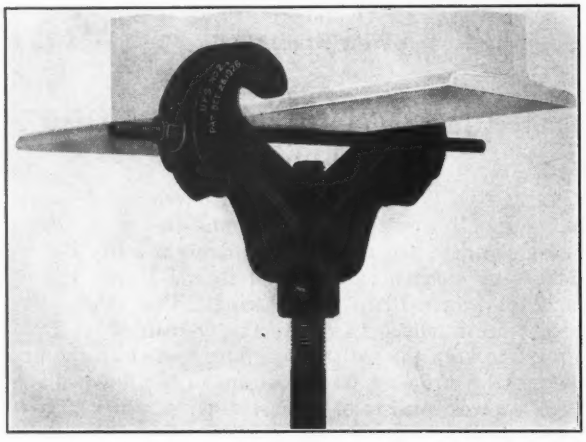


PISTON IN POWER CYLINDER F CONTROLS DRIVE TO VARY COAL FEED AND AIR SUPPLY TO GIVE EVEN PRESSURE

Position of this piston controls the rate of coal feed and air supply through its connections to the automatic device of the drive and the damper in the air duct connecting the forced draft fan and the stoker. As the coal feed and air supply are definitely tied together, the proper ratio of air and coal is maintained at all boiler loads. As the steam pressure decreases or increases, the piston of the power cylinder moves up or down an amount to feed sufficiently more or less coal and air to maintain an even pressure at that boiler rating. This control and the Riflex drive are products of Riley Stoker Corp., Worcester, Mass.

I-Beam Clamps for Piping

FOR SUSPENDING pipe from I-beams, a new universal forged steel I-beam clamp, as shown herewith, has recently been placed on the market by Grinnell Co., 260 West Exchange St., Providence, R. I. These clamps are made in three sizes: No. 1 for supporting pipe from



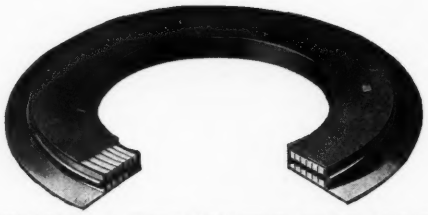
HOW THE I-BEAM CLAMP IS USED

¾-in. to 4-in. size; No. 2 for 6-in. to 12-in. pipe; No. 3 for 14-in. to 24-in. pipe. They have a factor of safety of 12, as called for by the specifications of the Power Piping Society based on supporting 12 ft. of extra-heavy pipe of maximum size filled with water.

When used with hanger rods as specified, these clamps permit a minimum vertical adjustment at the clamps of 1 in. on any width beam. They are designed to be used also with adjustable wrought pipe clamps, single pipe rolls, adjustable swivel pipe rolls, adjustable swivel rings and spring pipe hangers. Dimensions of beams, hanger rods and other parts are given in a bulletin published by the manufacturers.

Armor-Clad Flexitallic Gasket

ANNOUNCEMENT of a gasket designed to take care of the most severe modern service conditions—high pressure, high temperature and even acid conditions—has recently been made by the Flexitallic Gasket Co., Camden, N. J. Condensation in the lines, it is claimed, has no effect, making it suitable for plants carrying a variable load. The improvement consists of a simple, one-piece, metallic armor spun around the Flexitallic gasket. The gasket is designed to maintain



FLEXITALLIC GASKET ARMORED WITH ALUMINUM

its flexibility indefinitely and to be installed easily, because it does not require much tightening.

Tests conducted on this new gasket in the laboratories of Tinius Olsen of Philadelphia indicate that at the maximum capacity of the testing machine 100,000 lb., the elasticity of the gasket was not exceeded. This was equivalent to about 9000 lb. per sq. in.

The armor is made of thin sheet aluminum, which, it is stated, is rust resisting, acid resisting, capable of withstanding high temperatures and electrolytically neutral. Softness of the aluminum is intended to take care of rough and uneven surfaces.

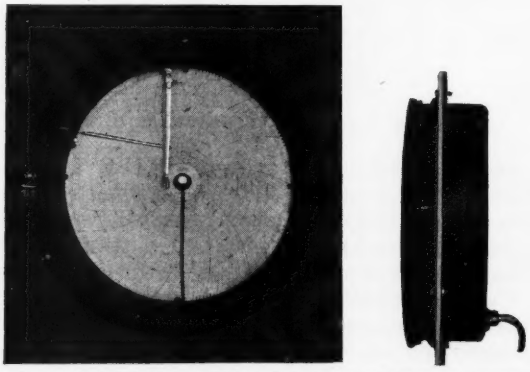
Another advantage claimed for armor-clad Flexitallic is the web which extends out to any width desired depending upon the inside diameter of the bolt circle. For example, if the inside diameter of the bolt circle is 10 in. and the inside diameter of the pipe is 6 in., the armor-clad Flexitallic is made in such a way that the gasket proper fits almost flush and concentric with the opening of the pipe, being held in place by the web which in turn is supported by the bolts.

The manufacturer states that the Flexitallic gasket will continue to be made and sold. On account of the necessarily higher cost of armor-clad, the old Flexitallic is still preferred for many purposes. Thus armor-clad Flexitallic will not be made at all for boiler tube caps and manholes, because the old Flexitallic handles such work satisfactorily, it is stated.

Flush-Mounted Instrument for Panel Boards

TO PROVIDE a flush-mounted instrument for panel board installations, C. J. Tagliabue Mfg. Co., Brooklyn, N. Y., has developed a new case.

Two styles of the round form case are offered, both of which are identical except for the location of the



LEFT—FRONT VIEW OF NEW FLUSH-MOUNTED INSTRUMENT. RIGHT—SIDE VIEW SHOWING HOW RING IS SHRUNK ON FOR FLUSH MOUNTING

mounting ring. This ring is shrunk on the case either just below the door (for flush mounting, as illustrated) or at the rear of the case (for wall mounting). The case, door ring and mounting ring are made of ⅛-in. pressed steel and all are finished in crystallized black, making an exceedingly handsome appearance. Case is moisture, fume and dust proof; a rubber gasket also extends between the glass and retaining ring.

Two New Traps Have Anum-Metl Parts

TWO NEW STEAM TRAPS have recently been announced, their principal features being shown in the accompanying illustrations. The first of these is the Strong inverted bucket trap, 20 Series, shown in Fig. 1.

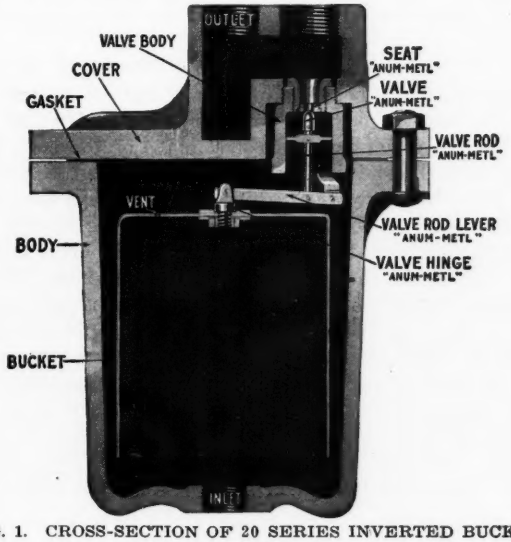


FIG. 1. CROSS-SECTION OF 20 SERIES INVERTED BUCKET TRAP

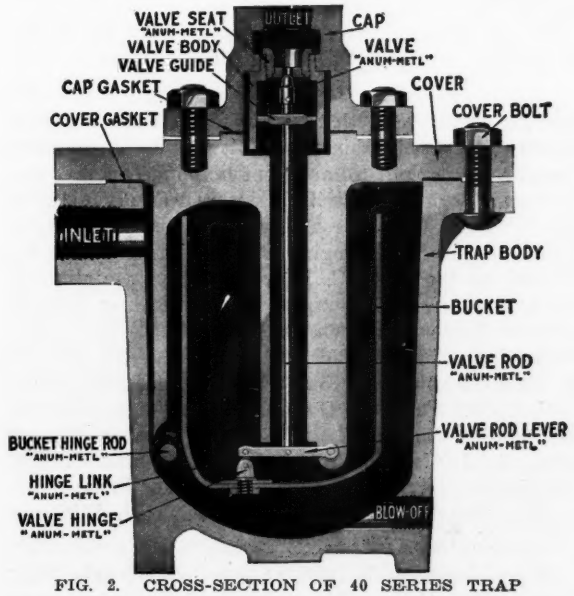


FIG. 2. CROSS-SECTION OF 40 SERIES TRAP

Principal parts of the unit and the method of its operation are clearly shown in this cross-section. One of its chief features is that Anum-Metl has been used for the valve and seat, valve rod and all levers and pins. These traps are made for pressures up to 225 lb. per sq. in. Based on 125 lb. pressure and using the proper seat orifices, their capacities range from 800 lb. of water an hour to 12,000 lb. an hour corresponding to a respective range of from 2400 to 36,000 sq. ft. of radiation. For operation at 250 lb. pressure, these capacities are multiplied by a factor of 0.5 while for 10 lb. pressure, the factor is 2.5.

Like the 20 series trap, the new 40 series unit shown in Fig. 2 is also fitted with parts of Anum-Metl as indicated. This unit is designed to have an exceptionally powerful operating mechanism and is of the intermittent type. This series also is made for pressures of 0 to 225 lb. per sq. in. and in capacities (based on 125 lb. pressure) of from 1000 lb. of water an hour to 22,000 lb., corresponding to radiation surfaces of from 3000 sq. ft. to 66,000 sq. ft. Factors for other pressures are the same as for the 20 series trap.

Because of the extensive use of Anum-Metl in these traps, their manufacturer, Strong, Carlisle & Hammond Co., Cleveland, Ohio, states that if a leak develops at valve and seat or if it becomes necessary to replace any other parts within one year, such replacements will be made without charge.

A.S.T.M. Reports Progress at Spring Group Meeting

AT THE ANNUAL SPRING group meeting of various committees of the American Society for Testing Materials, held in Chicago in March, some of the subcommittees reported activities that should be of interest to power plant engineers. Committee A-1 on Steel has recommended for advancement to standard, including revisions; tentative specifications for carbon-steel castings for valves, flanges and fittings for high-temperature service, which has been under discussion during the past 3 yr.; for lap-welded and seamless steel pipe for high-temperature service; for other specifications including those for lap-welded and seamless steel and lap-welded iron boiler tubes.

Committee A-2 on Wrought Iron approved certain revisions in the specifications for wrought iron pipe and boiler tubes. The changes affected the scope, form of bend test specimen, workmanship and threading clauses in the former and the table of weights and the workmanship clauses in the latter.

Committee A-5 on Corrosion of Iron and Steel discussed the results that have been obtained from tests of atmospheric corrosion of various groups of iron and steel sheets, at Pittsburgh and Fort Sheridan, the tests at Annapolis being still in progress.

Committee A-6 on Magnetic Properties considered the list of magnetic terms, definitions and symbols and agreed to submit this list for adoption as standard with certain minor revisions. Requirements for testing magnetic core materials at low inductions and commercial frequencies for use in current and audio frequency transformers were considered in some detail. Methods of testing magnetic materials such as magnet steels and the like with intense magnetic fields were discussed.

Committee D-5 on Coal and Coke recommended to the Society for advancement to standard the following

items: tentative method for the determination of sulphur in coal and coke by the bomb-washing and sodium peroxide fusion methods; tentative method of test for cubic foot weight of crushed bituminous coal; tentative method of test for cubic foot weight of coke; tentative method of test for sieve analysis of coke; tentative method of tumbler test for coke.

The following were approved for presentation to the Society as tentative standards: tentative method of test for sieve analysis of crushed bituminous coal; tentative method of test for size of anthracite.

Arrangements were made at the meeting for the continuation of coöperative sampling experiments to deter mine allowable tolerances when two or more samplers independently sample the same shipment of coal by the present A. S. T. M. standard method and by other methods involving the taking of smaller gross samples. From these data, it is hoped to establish tolerances for different methods of sampling.

Considerable progress was reported in an investigation being conducted in the laboratory of the General Motors Corp. as to a method for the determination of combustibility of coke and its relation to the performance of the coke in the cupola.

The sectional committee on standardization of Dimensions and Material of Wrought-Iron and Wrought-Steel Pipe and Tubing laid out a definite program of activities which is expected to result in the preparation of joint A. S. T. M. and A. S. M. E. specifications for all classes of pipe. Full details of the activities of the Society and its various subcommittees can be obtained by any one interested from C. L. Warwick, Secretary-Treasurer, American Society for Testing Materials, 1315 Spruce St., Philadelphia, Pa.

Consumers Power Co. Plans 40,000-hp. Development at Oxbow

Consumers Power Co., Jackson, Mich., has filed application at White Cloud, Mich., for a permit from the Newaygo County Board of Supervisors, to construct a 100-ft. dam on the Muskegon River at Oxbow, approximately 6 mi. up-stream from the company's present dam at Croton. It is stated that the new Oxbow dam will be bigger in every dimension than any other water power plant on the company's system and the highest earthwork embankment project of its kind in the world.

Under the provisions of the permit sought by Consumers Power Co., work will start this year on the project by Stevens & Wood, Inc., engineers and constructors and the plant should be completed during 1931. A new lake created by this construction project will have a maximum depth of 100 ft. It will be some 16 or 18 mi. in length and about a mile and a half across at its widest point. Every stick of standing timber in the proposed lake-bed will be taken out before the valley is flooded, with the idea of making this body of water one of Michigan's most attractive beauty spots. It is announced that Consumers Power Co. will carry on its reforestation program further to beautify and develop the valley and plant millions of game fish in an effort to restock a stream that has been sadly depleted during the last decade.

According to the company's engineers, the operating schedules for the station contemplate an annual production of some 80,000,000 kw-hr. of electrical energy, which means that more than 60,000 t. of the highest grade West Virginia coal will be conserved for other industrial requirements.

The new dam will have a total length of some 3500 ft. and will be of reinforced earthwork construction, with a heavy concrete corewall from base to crest and either a concrete or welded steel facing for the embankment on the up-river slope. Depth of water behind the dam will be approximately 100 ft. The volume of water impounded will be nearly 9,000,000,000 cu. ft. The modern type of concealed or conduit spillways will be installed, similar to the installation at Hodenpyl dam on the Manistee and Alcona and Mio on the Au Sable. There will be three of these great steel pipes encased in reinforced concrete, with an inside diameter of 14 ft. to carry water through and under the dam rather than over it as was the practice with the old method of open spilling.

Unlike most of the Consumers Power Co. hydroelectric plants, the power house will not be a part of the dam structure itself, but will be located about at tail-water level at the down-stream toe of the embankment. Steel conduits encased in reinforced concrete will carry water for the turbines and spillways from an intake tower of 45 ft. inside diameter and 125 ft. in height located just up-stream from the dam. This tower will rise above the lake level, with a one-story brick super structure housing an operating and repair room at the top, reached by a suspension type foot-bridge from the crest of the dam. In this super structure will be the emergency controlling mechanism for the gates and apparatus for cleaning racks or screens over the intakes. In all normal operation, the gates will be remote controlled from the power house. Three vertical, alternating-current generators will be installed in the power house, driven by three modern water turbines; generating capacity of the plant will be about 40,000 hp.

News Notes

American Society of Civil Engineers, with headquarters at 33 W. 39th St., New York City, has been admitted to membership in the American Engineering Council, according to a recent announcement. The American Society of Civil Engineers was organized in 1852 and has a membership as of January 1, 1929, of 13,577 professional engineers. Delegates thus far selected by the A. S. C. E. to have representation on the A. E. C. are as follows, for the term ending January 1, 1930: Baxter L. Brown, St. Louis, Mo.; L. L. Calvert, Philadelphia, Pa.; A. J. Dyer, Nashville, Tenn.; George T. Seabury, New York City; C. E. Grunsky, San Francisco, Calif.; Frank N. Gunby, Boston, Mass. For the term ending January 1, 1931: H. S. Crocker, Denver, Colo.; A. J. Hammond, Evanston, Ill.; John C. Hot, Washington, D. C.; Anson Marston, Ames, Iowa; Francis Lee Stuart, New York City; Frank M. Williams, Albany, N. Y.

From June 24-27, 1929, at the Pennsylvania State College, State College, Pa., a second joint meeting of the Oil and Gas Power Division of the American Society of Mechanical Engineers, will be held in coöperation with the Second Oil Power Conference of the Pennsyl-

vania State College. An excellent technical program is promised and an extra day this year is intended to allow more time for recreation and inspection of exhibits. This year the exhibits will be conveniently located on the first floor of the armory, directly across the street from the Schwab Auditorium, where the technical sessions are held. Income from the exhibit will be used to support the Fuel Oil Spray Research now under way at the college after the cost of putting on the exhibit has been paid. Complete details regarding the technical program and arrangements for the exhibit may be obtained from F. G. Hechler, chairman of the committee at Pennsylvania State College.

AMERICAN INSTITUTE OF STEEL CONSTRUCTION, INC. announces that the executives offices of the organization are now located in the International Combustion Building, 200 Madison Ave., New York City.

JOSEPH G. WORKER has just been elected vice-president of the Electrical Hoist Manufacturers' Assn. Mr. Worker is director of the American Engineering Co., Philadelphia, Pa., and is in charge of its sales activities. He was recently elected director of the American Fluid Motors Co. of Philadelphia, also of Affiliated Engineering Companies, Ltd., of Montreal, Canada, and of Juruick Refrigeration, Inc., New York City. He is director and former president of the Stoker Manufacturers' Assn.

PETTY & WHERRY, New York City and Brooklyn, N. Y., have just purchased the business, stock and good will, etc., of The Coleman Power Transmission Co. of Brooklyn, N. Y.

BOARD OF DIRECTORS of the Joseph Dixon Crucible Co., Jersey City, N. J., at their regular meeting March 18, 1929, elected Henry W. Armstrong treasurer of the company to succeed the late William Koester. Mr. Armstrong, a native of Jersey City, entered the employ of the Dixon Co. in 1903 as office boy and later became a stenographer in the export department, finally being transferred to the crucible sales department. In July, 1920, he was appointed credit manager and in 1926 he was elected assistant treasurer.

ANNOUNCEMENT is made that the offices of the American Engineering Co., Stoker Division, are being moved from 100 Broadway to the American Radiator Building, 40 West 40th St., New York City.

AMERICAN FOREST PRODUCTS CO., INC. announces the removal of its office on April 1, 1929, to the Chanin Bldg., 122 East 42nd St., New York, Room 2308.

MOTT & MCELRATH ENGINEERING CORP., 249 W. 18th St., New York City, has been appointed representative in the Metropolitan District by the Orton Crane & Shovel Co., Chicago, Ill. Sales of Orton products will be under the direction of John Connell of the Mott & McElrath Engineering Corp.

DANIEL W. SNYDER, JR. has succeeded L. A. Pettit, Jr., new elected vice president of the United Light and Power Corp., as president of the Missouri Power and Light Corp., with headquarters in Kansas City, Mo., where he will supervise that subsidiary of the North American Light and Power Co., serving 150 Missouri communities. Mr. Snyder has been identified with various departments of the Illinois Power & Light Co. in Clinton and Bloomington, Ill., and for 5 yr. has been chief operating executive in charge of 500 mi. of electrified railway operated by the Illinois Terminal System in central Illinois and the St. Louis district.

BOARD OF WATER COMMISSIONERS, Water Board Building, Detroit, Mich., will receive bids until May 15 for motor-driven pumping equipment for installation at the Springwells waterworks station, comprising 12 pumps and auxiliary equipment, two pumps having a rated capacity of 30,000,000 gal. a day, six pumps, with capacity of 40,000,000 gal. a day and four pumps, with rating of 50,000,000 gal. a day; all motor-driven, centrifugal, horizontal shaft type; delivery to be complete by July 1, 1931, all as per plans and specifications on file at the office of the board. George H. Fenkell is general manager and chief engineer.

JOHNS-MANVILLE CORP., New York City, announces with great sorrow the death on March 6 at Del Monte, Calif., of its president, Theodore Frelinghuysen Merseles. Mr. Merseles was born in 1863, began his career as clerk and stenographer with the Pennsylvania Railroad and Truck Line Assn. and then entered the bicycle manufacturing field, eventually combining the Western Wheel Works with the factories of A. A. Pope and A. G. Spalding, resulting in the American Bicycle Co., with Mr. Merseles as vice-president. In 1903, he joined the National Cloak and Suit Co., remaining with this organization for 18 yr., becoming vice-president and general manager. In 1920, he became president of Montgomery Ward and Co. and in 1927 was appointed president of the Johns-Manville Corp.

C. R. STEWART, formerly assistant to consulting engineer and power engineer with the Raritan Copper Works at Perth Amboy, N. J., has joined Stone & Webster Engineering Corp., Boston, Mass., as engineer in the mechanical division. Mr. Stewart is a graduate of Penn. State College, and has spent several years with the Southern California Edison Co., Standard Oil Co. at El Segundo, Calif., and with the Inspiration Consolidated Copper Co. at Miami, Arizona.

DAMPNEY COMPANY OF AMERICA, Hyde Park, Boston, Mass., announces the opening of a direct company branch office to serve the Metropolitan New York territory at Room 502 Engineering Bldg., 114 Liberty St., New York City.

WORTHINGTON PUMP & MACHINERY CORP., Harrison, N. J., announces that W. J. Denholm has been transferred from its Chicago office to the post of assistant to the manager of the Harrison Works, Harrison, N. J.

J. C. LINCOLN, formerly president of the Lincoln Electric Co., Cleveland, Ohio, has been given the position of chairman of the board of directors. The presidency is to be filled by J. F. Lincoln, formerly vice-president, and A. F. Davis becomes vice-president. The new arrangement will give J. C. Lincoln additional time to devote to electrical research and experimental development in the field of electric arc welding.

BY SPECIAL ARRANGEMENT between the National District Heating Association and Purdue University, the third District Heating School under N. D. H. A. auspices, will be held May 20 to 25, at Purdue University, Lafayette, Indiana. Only one course will be given this

year; it will include the following: accessory apparatus, flow of fluids, meters, new methods of steam heating, flow of steam in pipes, design and construction of underground structures, losses in distribution systems, welding, theory of rates, method of estimating consumption and maximum demand and so on. Anyone interested in district heating is invited to enroll; membership in the N. D. H. A. is not required. Registration desk will be on the main floor of Mechanical Engineering building and a charge of $10 will be made for the week's tuition. The school will begin at 10:00 a. m. on Monday, May 20.

CONRAD G. HIGH, who for the past 10 yr. has been associated with the Penn Planing Mill Co., has been appointed to the sales staff of the Reading Iron Co.'s Reading district office, Reading, Pa. A. C. Knight, formerly of the Oversole Rubber Corp., New York City, has been added to the selling staff of the New York office.

ANNOUNCEMENT IS MADE that the name of the American Spiral Pipe Works has been changed to Taylor Forge & Pipe Works. The main office and works are in Chicago, Ill.

PACKARD MOTOR CAR CO., 1580 East Grand Blvd., Detroit, Mich., has filed plans for addition to power plant, reported to cost about $175,000 with equipment.

AT THE ANNUAL MEETING of stockholders and directors of the Reading Iron Co., held April 9, 1929, at the company's general offices in Reading, Pa., the following officers were elected for the ensuing year: L. E. Thomas, president; John M. Callen, vice president; P. N. Guthrie, Jr., vice president; R. J. Wenger, vice president; Geo. W. Delany, secretary; Henry N. Yost, treasurer.

HAHN ENGINEERING CO. announces that it has become a division of the Lancaster Iron Works, Inc., Lancaster, Pa., and has moved its main office from its former location at 20th St. and Indiana Ave., Philadelphia, Pa., to the main office and works of the Lancaster Iron Works, Inc.

MURRAY IRON WORKS CO., Burlington, Iowa, announces the following appointments of sales agencies for its products: Frederick E. Bausch, 1605 Chemical Bldg., St. Louis, Mo.; T. T. Burchfield Co., 604 Arch St., Philadelphia, Pa.; W. B. Tardy, 74 Knickerbocker Bldg., Baltimore, Md.

E. F. HOUGHTON & CO., Philadelphia, Pa., announces with profound sorrow the death of its president, Charles E. Carpenter, on Saturday, April 6, 1929, at Miami Beach, Florida.

ALLEN-BRADLEY CO., Milwaukee, Wis., announces the appointment of John McC. Price as district manager in charge of the Chicago territory with office at 500 No. Dearborn St., Chicago, Ill.

NEVADA, IOWA, City council at a special meeting recently awarded contracts for a 2000-kw. turbine-generator and condenser and a centrifugal boiler feed pump for the municipal light plant. The General Electric Co., on its bid for $38,000, got contract for the turbine-generator; the Elliott Co., on its bid of $11,277, got contract for the condenser and the De Laval Steam Turbine Co., contract for the pump. The new equipment will more than double the present capacity of the municipal plant.

LEEDS & NORTHRUP CO., Philadelphia, Pa., announces the appointment of Bradshaw & Co., 530 Fourth Ave., Pittsburgh, Pa., as its exclusive sales agent.

CITY COUNCIL, Indianapolis, Ind., has approved final plans for a proposed new power plant at the city hospital and will make a call for bids on general contract within 30 to 60 days. A fund of $530,000 has been approved for the unit, which will have sufficient capacity for requirements for a number of years to come. C. R. Ammerman, Continental Bank Building, Indianapolis, Ind., is engineer in charge of the project and bids will be called from that office.

CENTRAL ILLINIOIS PUBLIC SERVICE Company has been granted 20-yr. franchise by the Pana, Ill. city council to operate in that city.

EASTMAN (Wis.) municipal light plant has been acquired by the Interstate Power Co., which will build a new high line from Seneca to Eastman and will install a new distribution system; 24-hr. service will be given under the new operation. The new high power line will require 3 mo. for construction.

SULLIVAN MACHINERY CO. announces that on April 26 its general office and all departments were moved from Peoples Gas Bldg., 122 So. Michigan Ave., to new headquarters on the 7th and 8th floors of the Wrigley Bldg., 400 No. Michigan Ave., Chicago, Ill.

WEST FLORIDA POWER CORP., Jasper, Fla., has work under way on a new hydroelectric plant at Jackson Bluff on the Ocklocknee River, about 25 mi. from Tallahassee. It will be equipped for an initial capacity of 13,000 hp. in three units, using Westinghouse generators with water wheels made by the Newport News Shipbuilding & Dry Dock Co. The West Florida Co. is a subsidiary of the National Electric Power Co., New York.

TOCCOA ELECTRIC POWER CO., a subsidiary of The Tennessee Electric Power Co., has engaged Stevens & Wood, Inc., of New York and Nashville, to complete the work on its 20,000-hp. hydroelectric plant on the Toccoa River near Blue Ridge, Ga. The dam is to be 165 ft. high and the pond when filled will cover about 4400 acres of land. This work is to be pushed rapidly to completion but it is anticipated that it will require about two years; total cost will be in the neighborhood of $4,500,000.

PHILADELPHIA & READING COAL & IRON CO., Reading Terminal, Philadelphia, Pa., has acquired property at Herndon, near Sunbury, Pa., and plans construction of a large steam-operated electric generating plant at that location. A power dam is to be constructed across the Susquehanna River in connection with the enterprise. The plant will be equipped to use pulverized coal, a byproduct of the daily operation of the numerous collieries in this vicinity, and is estimated to cost close to $5,000,000. A steel tower transmission line will be built to utilize service from the plant at a number of electric-operated coal breakers which the company proposes to build in this district. It is planned to centralize operations at the new breakers to eliminate an existing

group of about 40 of these plants in different parts of the anthracite coal region. The entire expansion program will be carried out at a gross estimated cost approximating $30,000,000, and the company is arranging financing in that amount. A. J. Maloney is president.

GLADBROOK-SALEM, Iowa, Electric Co., owned by 56 farmers in that community, rejected, by a large majority, a proposal to sell the distribution system, which has been supplied by the Iowa Railway & Light Corp., to the utilities corporation. The farmer-owners had been offered $500 in electrical appliances or $300 worth of appliances and $200 in preferred stock for each share, originally costing between $400 and $500.

STOCKHOLDERS of the Illinois Power & Light Corp., at their annual meeting in the legal headquarters of the corporation in Monticello, Ill., recently reëlected directors as follows: Clement Studebaker, Jr., president; George M. Studebaker, George T. Buckingham, J. E. Otis, H. L. Hanley, O. N. Custer, P. L. Smith, Stephen E. and E. N. Hurley. E. S. Hight, assistant to the vice president in charge of operations and chief engineer, in a brief statement to the stockholders stated that the utilities company now has 60 mi. of 132,000-v. transmission lines in operation; 75 mi. of 66,000-v. lines and 1500 mi. of 33,000-v. lines, serving more than 400,000 customers in its territory with plans to extend service intensively in the territory as rapidly as possible. In addition, the company has 150 mi. of gas main in the East St. Louis industrial area and is planning establishment of a great terminal in St. Louis to serve the newly organized Illinois Terminal Railroad System, built around its Illinois Traction System, which was nucleus of recent merger in the interurban field last year.

GREAT LAKES DIVISION, National Electric Light Assn., announces that its new address is 910 Marquette Bldg., 140 So. Dearborn St., Chicago, Ill., telephone Franklin 1987.

ACCORDING to a recent announcement by R. H. Ballard, of the Southern California Edison Co., Los Angeles, Calif., the new unit on which construction has just started is scheduled for completion early next year. This is a 134,000-hp. turbine generator similar to the one already installed in Long Beach plant No. 3.

ON MAY 1, the Chicago district and Central Division offices of the various units of the Union Carbide and Carbon Corp., including Linde Air Products Co., Prest-O-Lite Co., Inc., Oxweld Acetylene Co., Oxweld Railroad Service Co., Union Carbide Sales Co., Carbide and Carbon Chemicals Corp., National Carbon Co., Inc., Haynes Stellite Co., J. B. Colt Co. and Acheson Graphite Co., moved to its new 40-story building at Michigan Ave. and So. Water St., Chicago. In this building, color has been freely used in exterior decoration, including black granite for the base, green and terra cotta tile for the sides and gold terra cotta as relief.

A basement garage for tenant's cars, complete artificial ventilation to all offices, refrigerated drinking water, an exhibit of the company's products in a street-level room and oxwelded piping for a major part of the building system are special features. All steam lines 2½ in. and over are welded.

Catalog Notes

MINIMUM RESALE prices on wrought iron pipe have been established by A. M. Byers Co., Pittsburgh, Pa., in its card R. S. 102 dated April 1, superseding that of March 25.

COPPER-BEARING STEEL PIPE, its application, results of comparative tests, and illustrations showing its resistance to corrosion are discussed in bulletin No. 11, just issued by National Tube Co., Frick Bldg., Pittsburgh, Pa.

HEATING RATES for 1928-1929 have recently been published in tabulated form by the Ric-wiL Co., Union Trust Bldg., Cleveland, Ohio, available to anyone interested in comparing the charges made by district heating companies in cities throughout the country for hot water and steam heating.

EQUALIZED PRESSURE DRAINAGE Saves Fuel is the title of a recent bulletin showing how this can be done by use of drainage receiver pumps, boiler feeding systems and fuel saving systems. These employ equipment manufactured by the Farnsworth Co., Conshohocken, Pa.

DUPLEX AIR COMPRESSORS in single-stage and 2-stage types and in types for direct connection to electric motor or for belt drive, are described and illustrated with details of valves, cylinders and other parts, in a 16-page bulletin, No. 144 by Pennsylvania Pump & Compressor Co., Easton, Pa. Considerable space is devoted in this bulletin to the advantages of the synchronous motor drive for such compressors.

BLOW GUNS and forge blowers for the use of compressed air in dusting and cleaning processes in industrial plants are described in bulletin 4-T by Schutte & Koerting Co., Philadelphia, Pa. The SK flow indicator to be inserted in pipe lines so that the flow of liquids can be observed is described in bulletin 6-F, while bulletin A-T describes the seatless valve. These bulletins are attractively illustrated in colors and contain much engineering information.

WAGNER ELECTRIC CORPORATION of St. Louis, Mo., has issued a new bulletin No. 161, containing instructions for the installation and operation of power and distribution transformers. The bulletin consists of 20 pages and goes into detail regarding not only the installation and operation of transformers but also their construction. The bulletin covers such subjects as location of transformers, their storage, handling and installation; drying core and coils; drying and testing oil; proper operating temperature.

SECOND EDITION of "Modern Valve Control Practice," the title of a book issued by Cutler-Hammer, Inc., Milwaukee, Wis., discussing the C-H automatic valve control system, has just been issued. This contains many data on uses of the system not contained in the original edition and many new photographs showing the installations. Construction and operating principle of the system are described in detail, including the new unit for small valves, considerable discussion is given to the control of all valves in the plant from a centralized control board.

Power Plant Construction News

Ala., Birmingham—The Virginia Bridge & Iron Co., Roanoke, Va., plans installation of power equipment in proposed new steel fabricating plant at Birmingham, Ala., entire project reported to cost more than $1,000,000.

Ala., Mobile—The Board of Commissioners has plans under way for the construction of steam-operated electric power plant to be used in connection with the municipal waterworks. An appropriation of $1,000,000, is being arranged for the plant and extensions in water system. The Burns & McDonnell Engineering Co., Interstate Building, Kansas City, Mo., is consulting engineer.

Calif., Alviso—The Alviso Salt Co., Russ Building, San Francisco, Calif., plans installation of power equipment in proposed new plant at Alviso, entire project reported to cost more than $200,000. A mechanical washing plant will be installed.

Conn., Hartford—The Wiremold Co., Asylum Street, will install power equipment in proposed new cable and conduit plant in the Elmwood district, where tract of 10 acres of land has been acquired, project reported to cost more than $100,000.

Colo., Pueblo—The Pueblo Lime Co., East Eighth Street, plans the installation of power equipment in connection with extensions and improvements in plant to cost upward of $40,000. Jay D. Thomas is general manager.

Fla., Lake Worth—The Southeastern Ice & Cold Storage Co. plans extensions and improvements in ice-manufacturing plant, including installation of additional equipment, estimated to cost close to $65,000. E. N. Andrews is general manager.

Ill., Chicago—The Evans Flexible Reamer Corporation, 3513 Lincoln Avenue, plans installation of power equipment in proposed three-story plant at Racine Avenue and North Clark Street to cost about $80,000. Guske & Foster, 3725 Devon Street, are architects.

Ind., Indianapolis—The Allison Engineering Co., Speedway City, recently acquired by new interests, plans installation of power equipment in connection with an expansion program at its aircraft engine and gear plant, reported to cost more than $500,000, to be carried out over a period of months.

Ind., Indianapolis—The Pennsylvania Railroad Co., Indianapolis Division, plans construction of an addition to power plant at its local Hawthorne shops in connection with an expansion and improvement program at that point to cost approximately $500,000. New boilers and other equipment will be installed.

Ind., Indianapolis—The real Silk Hosiery Mills, Inc., North Noble Street, will install power equipment in a new mill addition, entire project reported to cost in excess of $1,000,000.

Ind., Michigan City—The C. A. Dunham Co., 450 East Ohio Street, Chicago, Ill., manufacturer of heating apparatus, plans installation of power equipment in a proposed new main plant at Michigan City, on tract of more than 2 acres of land, entire project to cost more than $500,000. A boiler house is projected.

Iowa, Ottumwa—The Iowa Southern Utilities Co., Centerville, Iowa, has approved final plans for an addition to steam-operated electric power plant at Ottumwa, reported to cost in excess of $200,000, with equipment.

Iowa, Spirit Lake—The Iowa Public Service Co., Fort Dodge, Iowa, has authorized the immediate construction of a steam-operated electric power plant at Spirit Lake, reported to cost about $40,000.

La., Alexandria—The Refrigerated Products, Inc., recently formed by Edwin Harding, Alexandria, and associates, is planning construction of a one-story ice-manufacturing plant at Murray and Duke Streets, reported to cost close to $40,000, with equipment.

Md., Baltimore—The Continental Can Co., 100 East Forty-second Street, New York, is said to be planning the installation of power equipment in proposed addition to plant at Baltimore, project to cost about $100,000. Francisco & Jacobus, 511 Fifth Avenue, New York, are engineers.

Mo., Hannibal—The International Shoe Co., St. Louis, Mo., is said to be planning the installation of power equipment in a proposed addition to its rubber footwear plant at Hannibal, project reported to cost about $70,000.

Mo., Jefferson City—The Moerschel Products Co., Jefferson City, is arranging for the construction of an electric-operated ice-manufacturing plant, estimated to cost more than $80,000, to replace a present steam-operated unit.

Mo., Maryville—The Maryville Milk Co., Maryville, plans installation of power equipment in proposed new creamery, entire project to cost about $200,000. The Douthitt Engineering Co., 139 North Clark Street, Chicago, Ill., is engineer.

Neb., Broken Bow—The Common Council has plans in progress for a municipal power plant to cost upward of $50,000. Grant & Fulton, 525 South Thirteenth Street, Lincoln, Neb., are engineers.

N. H. Laconia—Scott & Williams, Inc., Laconia, has authorized the construction of a boiler house in connection with an expansion program at knitting machinery manufacturing plant. Entire project will cost about $100,000.

N. J., Asbury Park—The City Council, City Hall, has plans for a two-story municipal steam power plant, for central heating service in the beach section, reported to cost more than $500,000, with equipment. Warren & Wetmore, 16 East Forty-seventh Street, New York, are architects.

N. J., Trenton—The Magnetic Pigment Co., Cass Street, plans installation of power equipment in proposed new four-story factory unit on Woolverton Street to cost close to $90,000.

N. Y., Brooklyn—The George E. Sherman Soap Co., 153-7 Classon Avenue, plans installation of power equipment in connection with proposed rebuilding of portion of plant recently destroyed by fire with loss estimated at close to $100,000.

N. Y., Mechanicville—The R. A. M. Brick Co. plans the installation of power equipment in connection with proposed rebuilding of its plant recently destroyed by fire with loss reported at close to $100,000. A boiler house is proposed.

Ohio, Cleveland—The Hupp Chandler Corporation, St. Claire Avenue, plans installation of power equipment in connection with proposed expansion and improvement program at automobile plant to cost more than $200,000. Ernest McGeorge, 3030 Euclid Avenue, is architect and engineer.

Pa., Carnegie—The W. C. Hardesty Co., Inc., Rosslyn Farms, near Carnegie, plans installation of power equipment in connection with proposed rebuilding of portion of grease and oil works destroyed by fire, April 14, with loss reported at more than $300,000.

Pa., Johnson—The Bethlehem Steel Co., South Bethlehem, Pa., plans installation of power equipment at its Cambria Works, Johnstown, Pa., in connection with an expansion and improvement program to cost upward of $3,000,000.

Pa., New Kensington—The Aluminum Co. of America, Oliver Building, Pittsburgh, plans installation of power equipment in proposed addition to plant at New Kensington, entire project reported to cost more than $350,000.

Tenn., Bristol—The Mutual Thread Co., 17 West Seventeenth Street, New York, plans installation of power equipment in proposed mill at Bristol estimated to cost $150,000. C. B. Kearfott, Briston, is achitect.

Ohio, Orrville—The Board of Public Affairs is completing plans for a one-story addition to the municipal power plant, to be equipped primarily as a boiler department, estimated to cost $45,000. Hadlow, Hick & Conrad, 806 Euclid Avenue, Cleveland, Ohio, are engineers.

Oklahoma, Ponca City—The Oklahoma Gas & Electric Co., Oklahoma City, is said to be arranging for immediate erection of superstructure for a new power plant at Ponca City, entire project to cost upward of $350,000, with equipment.

Ore., Portland—The Albina Machine Works, Inc., plans installation of power equipment in connection with proposed rebuilding of portion of plant recently destroyed by fire with loss reported at close to $90,000.

Texas, Houston—The Tidal Refining Co., a subsidiary of the Tide Water Oil Co., 11 Broadway, New York, plans the installation of power equipment in connection with a proposed refining plant on the Houston ship channel, entire project reported to cost more than $2,000,000. A boiler house is proposed. Site for refinery has been acquired.

Wis., Madison—City Council, W. R. Winckler, city clerk, has rejected bids recently received for a motor-driven centrifugal pumping unit, and proposes to make purchase in the open market.

Wis., New London—The Hamilton & Sons Canning Co. plans installation of power equipment in proposed addition to factory, entire project reported to cost more than $75,000.